Nondiscrimination Policy
The Massachusetts Institute of Technology is committed to the principle of equal opportunity in education and employment. The Institute does not discriminate against individuals on the basis of race, color, sex, sexual orientation, gender identity, religion, disability, age, genetic information, veteran status, ancestry, or national or ethnic origin in the administration of its educational policies, admissions policies, employment policies, scholarship and loan programs, and other Institute administered programs and activities, but may favor US citizens or residents in admissions and financial aid.

The Vice President for Human Resources is designated as the Institute’s Equal Opportunity Officer and Title IX Coordinator. Inquiries concerning the Institute’s policies, compliance with applicable laws, statutes, and regulations (such as Title VI, Title IX, and Section 504), and complaints may be directed to the Vice President for Human Resources, Room E19-215, 617-253-6512, or to the Manager of Staff Diversity and Inclusion, Room E19-215, 617-452-4516. In the absence of the Vice President for Human Resources or the Manager of Staff Diversity and Inclusion, inquiries or complaints may be directed to the Executive Vice President, Room 3-211, 617-253-3928, or to the Director of Labor and Employee Relations, Room E19-235N, 617-253-4264, respectively. Inquiries about the laws and about compliance may also be directed to the Assistant Secretary for Civil Rights, US Department of Education.

Accreditation
MIT is accredited by the New England Association of Schools and Colleges, Inc., through its Commission on Institutions of Higher Education.

Inquiries regarding MIT’s accreditation status should be directed to the Office of the Vice President and Secretary of the Corporation, Massachusetts Institute of Technology. Individuals may also contact:

Commission on Institutions of Higher Education
New England Association of Schools and Colleges
209 Burlington Road
Bedford, MA 01730-1433
telephone 781-271-0022
e-mail cihe@neasc.org.

Many degree programs at MIT are accredited by specialized professional accrediting bodies, including the Association to Advance Collegiate Schools of Business, the Accreditation Board for Engineering and Technology, the American Chemical Society, the American Institute of Chemical Engineers, the Computer Science Accreditation Board, the National Architectural Accrediting Board, and the Planning Accreditation Board. Academic departments can provide information on the accreditation of the specific degree programs they offer.

Issues of the MIT Bulletin
The MIT Course Catalog is available in September and can be viewed online at http://web.mit.edu/catalog/. To obtain a print copy, visit http://web.mit.edu/referencepubs/catalog/getacopy.html.

The Institute reserves the right to make changes in the courses and regulations announced in the MIT Bulletin. Please send questions or comments to MIT Bulletin, Room E38-254, 77 Massachusetts Avenue, Cambridge, MA 02139-4307.

Summer Session
During the regular Summer Session, MIT offers a limited selection of the subjects available in the academic year, as well as a few subjects designed for the special interests and needs of MIT students. Current MIT undergraduate and graduate students are automatically eligible for participation in the Summer Session.

Undergraduate and graduate students from other colleges and universities may be admitted for the Summer Session as special (non-degree) students. International students living outside the United States are not permitted to apply for the summer session. The admission standards for the Summer Session are the same as those for the regular academic year.

Further information about the Summer Session can be found at http://web.mit.edu/catalog/summer/.
Bachelor of Science Degree Requirements

**School of Architecture and Planning**
Architecture/Course 4
Planning/Course 11

**School of Engineering**
Aerospace Engineering/Course 16-1
Aerospace Engineering with Information Technology/Course 16-2
Archaeology and Materials/Course 3-C
Biological Engineering/Course 20
Chemical-Biological Engineering/Course 10-B
Chemical Engineering/Course 10
Civil and Environmental Engineering/Course 1-A
Civil Engineering/Course 1-C
Computer Science and Engineering/Course 6-3
Electrical Engineering and Computer Science/Course 6-2
Electrical Engineering and Computer Science/Course 6-P
Electrical Science and Engineering/Course 6-1
Engineering as Recommended by the Department of Aeronautics and Astronautics/Course 16-ENG
Engineering as Recommended by the Department of Chemical Engineering/Course 10-ENG
Environmental Engineering Science/Course 1-E
Materials Science and Engineering/Course 3
Mechanical and Ocean Engineering/Course 2-OE
Mechanical Engineering/Course 2
Mechanical Engineering/Course 2-A
Nuclear Science and Engineering/Course 22

**School of Humanities, Arts, and Social Sciences**
Anthropology/Course 21A
Comparative Media Studies/Course CMS
Economics/Course 14
Foreign Languages and Literatures/Course 21F
History/Course 21H
Humanities/Course 21
Humanities and Engineering/Course 21E
Humanities and Science/Course 21S
Linguistics and Philosophy/Course 24-2
Literature/Course 21L
Music/Course 21M
Philosophy/Course 24-1
Political Science/Course 17
Science, Technology, and Society/Double Major/Course STS
Writing/Course 21W

**MIT Sloan School of Management**
Management Science/Course 15

**School of Science**
Biology/Course 7
Brain and Cognitive Sciences/Course 9
Chemistry/Course 5
Earth, Atmospheric, and Planetary Sciences/Course 12
Mathematics/Course 18
Mathematics with Computer Science/Course 18-C
Physics/Course 8

**Interdisciplinary Undergraduate Programs**
Computer Science and Molecular Biology/Course 6-7
WELCOME FROM THE PRESIDENT

Welcome!

When I arrived here more than 30 years ago as a faculty member, I quickly came to feel that MIT was my home. I found myself belonging to a passionate, dedicated “extended family” of brilliant people who always had the patience to answer my questions and were eager to help me succeed. The values of this community impressed me, too—the commitment to excellence, meritocracy and integrity; the impulse always to take the high road and do the right thing; and the passion for working on the big problems that make a difference for humankind.

I had never encountered such a community anywhere else. It inspired me to work harder and more creatively than I ever had before. I loved it then, and I still do.

If you know MIT well, I hope that you already share my enthusiasm for this energetic and energizing place. If you are here to learn about us, the Bulletin will orient you not only to our courses of study but also to the Institute as a whole. And whether you are a new student, a candidate for admission, a parent, or an educator, let me offer you a warm welcome on behalf of MIT.

With warm best wishes,

L. Rafael Reif
President
### 2012–2013 Academic Calendar

#### September

<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Mon</td>
<td>Labor Day—Holiday</td>
</tr>
<tr>
<td>4</td>
<td>Tue</td>
<td>Registration Day—Fall Term</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of class days (Wed, Sep 5, through Wed, Dec 12): 12 Mon, 13 Tue, 15 Wed, 13 Thu, 12 Fri = 65 days</td>
</tr>
<tr>
<td>5</td>
<td>Wed</td>
<td>Deadline to change a Spring Term Exploratory subject to Listener status</td>
</tr>
<tr>
<td>7</td>
<td>Fri</td>
<td>Registration deadline. Registration for all students must be submitted by this date. $50 Late Fee.</td>
</tr>
<tr>
<td>10</td>
<td>Mon</td>
<td>First day of classes</td>
</tr>
<tr>
<td>11</td>
<td>Tue</td>
<td>Degree Application deadline for February SB and Advanced Degrees. $50 Late Fee ($85 after December 14).</td>
</tr>
<tr>
<td>14</td>
<td>Fri</td>
<td>Degree Application deadline. Registration for all students must be submitted by this date. $50 Late Fee.</td>
</tr>
<tr>
<td>17–21</td>
<td>Mon–Fri</td>
<td>First quarter Physical Education classes begin</td>
</tr>
<tr>
<td>19</td>
<td>Wed</td>
<td>Graduate Academic Performance Meeting</td>
</tr>
<tr>
<td>21</td>
<td>Fri</td>
<td>CAP September Degree Candidates Meeting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Last day to sign up for family health insurance or waive individual coverage for fall, E23-308</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Career Week</td>
</tr>
<tr>
<td>17–21</td>
<td>Mon–Fri</td>
<td>Faculty Officers recommend degrees to Corporation</td>
</tr>
<tr>
<td>21</td>
<td>Fri</td>
<td>Student Holiday—no classes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fall Career Fair</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minor Completion Date. Deadline for submission of Minor Completion form for final-term seniors. $50 Late Fee.</td>
</tr>
</tbody>
</table>

#### October

<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Fri</td>
<td>ADD DATE. Last day to add subjects to Registration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Last day for juniors/seniors to change an elective to or from P/D/F grading</td>
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<tr>
<td></td>
<td></td>
<td>Last day for graduate students to change a subject to or from P/D/F grading</td>
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<tr>
<td></td>
<td></td>
<td>Last day to change a subject from Listener to Credit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Last day to drop half-term subjects offered in first half of term</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Last day for sophomores to change a subject to or from Exploratory</td>
</tr>
<tr>
<td>8–9</td>
<td>Mon–Tue</td>
<td>Late fee ($100) and petition required for students completing registration after this date</td>
</tr>
<tr>
<td>12–14</td>
<td>Fri–Sun</td>
<td>Last day for June and September 2013 degree candidates to apply for double major</td>
</tr>
<tr>
<td>29</td>
<td>Mon</td>
<td>Deadline for completing cross-registration. $50 Late Fee for petitions received after this date.</td>
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<tr>
<td></td>
<td></td>
<td>Columbus Day—Holiday</td>
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<tr>
<td></td>
<td></td>
<td>Family Weekend</td>
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<tr>
<td></td>
<td></td>
<td>Second quarter Physical Education classes begin</td>
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<tr>
<td></td>
<td></td>
<td>Veterans Day—Holiday</td>
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<tr>
<td></td>
<td></td>
<td>DROP DATE. Last day to cancel subjects from Registration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Last day to change a subject from Credit to Listener</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Last day to add a time-arranged subject that started after beginning of the term</td>
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<tr>
<td></td>
<td></td>
<td>Last day to add half-term subjects offered in second half of term</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Last day to petition for December Advanced Standing Exam (given during Final Exam Period)</td>
</tr>
<tr>
<td>22–23</td>
<td>Thu–Fri</td>
<td>Thanksgiving Vacation</td>
</tr>
</tbody>
</table>
DECEMBER

3 Mon

7 Fri

ONLINE PREREGISTRATION for Spring Term and IAP begins

SUBJECTS WITH FINAL EXAM—No test may be given and no assignment, term paper, or oral presentation shall fall due after this date.

SUBJECTS WITH NO FINAL EXAM—Undergraduate Subjects: No test may be given and at most one assignment may fall due between this date and the end of the last scheduled class period in the subject.

Graduate Subjects: Either one in-class test may be given or one assignment may fall due between this date and the end of the last regularly scheduled class in the subject.

LAST DAY OF CLASSES

Last day to drop half-term subjects offered in the second half of term

12 Wed

14 Fri

Subjects with final exam—No test may be given and no assignment, term paper, or oral presentation shall fall due after this date.

Subjects with no final exam—

Undergraduate Subjects: No test may be given and at most one assignment may fall due between this date and the end of the last scheduled class period in the subject.

Graduate Subjects: Either one in-class test may be given or one assignment may fall due between this date and the end of the last regularly scheduled class in the subject.

17–21 Mon–Fri

Final exam period

18–Jan 1 Tue–Wed

Grade deadline. Grades must be submitted according to due date indicated

19 Fri

Spring preregistration deadline. Continuing students must initiate online preregistration by 5 pm on this date. $50 Late Fee ($85 after January 21).

JANUARY

4 Fri

IAP PREREGISTRATION DEADLINE. Deadline for all students to preregister for IAP

Term Summaries of Fall Term grades available to departments

7 Mon

First day of January Independent Activities Period

DEADLINE FOR DOCTORAL STUDENTS to submit application, signed by department, to the Office of the Dean for Graduate Education, 3-138, for Spring Term Non-Resident status. $100 Late Fee. Not needed if Spring Term approved with Fall Term application.

IAP Physical Education classes begin

8 Tue

Graduate Academic Performance Grades Meeting

9–10 Wed–Thu

CAP Grades Meetings

11 Fri

Thesis due for doctoral degrees

18 Fri

Thesis due for degrees other than doctoral

LAST DAY TO GO OFF THE FEBRUARY DEGREE LIST

21 Mon

Martin Luther King, Jr. Day—Holiday

22 Tue

5 pm Final deadline for continuing students to preregister online for spring. $85 Late Fee.

23–24 Wed–Thu

CAP Deferred Action Meetings

28 Mon

Online registration opens for all students

English Evaluation Test for international students, 9 am–12 pm

FEBRUARY

1 Fri

Last day of January Independent Activities Period

REGISTRATION DAY—SPRING TERM

Number of class days (Tue, Feb 5, through Thu, May 16): 12 Mon, 12 Tue, 14 Wed, 14 Thu, 13 Fri=65 days

DEADLINE to change a Fall Term Exploratory subject to Listener status

First day of classes

Grade deadline. Grades for IAP must be submitted by this date

Registration deadline. Registration for all students must be submitted by this date.

$50 Late Fee.

Degree application deadline for June SB and Advanced Degrees. $50 Late Fee ($85 Late Fee after April 5).
DEADLINE FOR SECOND-TERM JUNIORS to submit the HASS Concentration Proposal form. $50 Late Fee.  
DEADLINE FOR FINAL-TERM SENIORS to submit the HASS Concentration Completion form. $50 Late Fee.  
Term Summaries of grades for IAP available to departments  
Third quarter Physical Education classes begin  
Graduate Academic Performance Meeting  
CAP February Degree Candidates Meeting  
Last day to sign up for family health insurance or waive individual coverage for spring, E23-308  
Presidents Day—Holiday  
MONDAY SCHEDULE OF CLASSES TO BE HELD  
Faculty Officers recommend degrees to Corporation  
MINOR COMPLETION DATE. Deadline for submission of Minor Completion form for final-term seniors. $50 Late Fee.  
ADD DATE. Last day to add subjects to Registration  
Last day for juniors/seniors to change an elective to or from P/D/F grading  
Last day for graduate students to change a subject to or from P/D/F grading  
Last day to change a subject from Listener to Credit  
Last day to drop half-term subjects offered in first half of term  
Last day for sophomores to change a subject to or from Exploratory  
Late fee ($100) and petition required for students completing registration after this date  
Last day for February 2014 degree candidates to apply for a double major  
Deadline for completing cross-registration. $50 Late Fee for petitions approved after this date.  
DROP DATE. Last day to cancel subjects from Registration  
Last day to change a subject from Credit to Listener  
Last day to add time-arranged subject that started after beginning of the term  
Last day to petition for May Advanced Standing Exam (given during Final Exam Period)  
Last day to add half-term subjects offered in second half of term  
ONLINE PREREGRISTRATION for Fall Term and Summer Session begins  
THESIS DUE for doctoral degrees  
SUBJECTS WITH FINAL EXAM—No test may be given and no assignment, term paper, or oral presentation shall fall due after this date.  
SUBJECTS WITH NO FINAL EXAM—Undergraduate Subjects: No test may be given and at most one assignment may fall due between this date and the end of the last regularly scheduled class period in the subject.  
Graduate Subjects: Either one in-class test may be given or one assignment may fall due between this date and the end of the last regularly scheduled class period in the subject.  
THESIS DUE for degrees other than doctoral
2013

16 Thu

**LAST DAY OF CLASSES**
Last day to drop half-term subjects offered in the second half of term

20–24 Mon–Fri

**FINAL EXAM PERIOD**

21–28 Tue–Tue

**GRADE DEADLINE.** Grades must be submitted according to due date indicated

24 Fri

**LAST DAY TO GO OFF THE JUNE DEGREE LIST**
Memorial Day—Holiday

30 Thu

Term Summaries of Spring Term grades delivered to departments

31 Fri

**DEPARTMENT GRADES MEETINGS**

**FALL PREREGISTRATION DEADLINE.** Continuing students must initiate online preregistration by this date.
$50 Late Fee ($85 after August 19).

**SUMMER SESSION PREREGISTRATION DEADLINE.** Deadline for all students to preregister online for Summer Session. $50 Late Fee.

JUNE

3 Mon

CAP June Degree Candidates Meeting
CAP Grades Meeting
Graduate Academic Performance Meeting
Faculty Officers recommend degrees to Corporation

**ONLINE REGISTRATION OPENS** for all students
Online registration opens for all students

4 Tue

CAP Grades Meeting

6 Thu

Doctoral Hooding Ceremony

7 Fri

**COMMENCEMENT**

10 Mon

**FIRST DAY OF CLASSES FOR REGULAR SUMMER SESSION**
CAP Deferred Action Meetings

12–13 Wed–Thu

**DEGREE APPLICATION DEADLINE** for September SB and Advanced Degrees. $50 Late Fee ($85 after July 13).

14 Fri

**REGISTRATION DEADLINE.** Registration for all students must be submitted by this date.
$50 Late Fee.

The Academic Calendar is available at [http://web.mit.edu/registrar/calendar/](http://web.mit.edu/registrar/calendar/).

Projected key dates for future academic years are available at [http://web.mit.edu/registrar/calendar/projected.html](http://web.mit.edu/registrar/calendar/projected.html).
Part 1

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

Teaching and research—with relevance to the practical world as a guiding principle—continue to be MIT’s primary purpose. The Institute is independent, coeducational, and privately endowed. Its five schools—architecture and planning; engineering; humanities, arts, and social sciences; management; and science—and college of health sciences and technology encompass numerous academic departments, divisions, and degree-granting programs, as well as interdisciplinary research centers, laboratories, and programs whose work extends beyond traditional departmental boundaries.

### Mission Statement

The mission of MIT is to advance knowledge and educate students in science, technology, and other areas of scholarship that will best serve the nation and the world in the 21st century.

The Institute is committed to generating, disseminating, and preserving knowledge, and to working with others to bring this knowledge to bear on the world’s great challenges. MIT is dedicated to providing its students with an education that combines rigorous academic study and the excitement of discovery with the support and intellectual stimulation of a diverse campus community. We seek to develop in each member of the MIT community the ability and passion to work wisely, creatively, and effectively for the betterment of humankind.

### Around Campus

The 1998 Task Force on Student Life and Learning described MIT’s educational goals in these terms: An MIT education should prepare students for life through an integrated educational program composed of academics, research, and community. Academics establish a place for rigorous study of the fundamentals of science, engineering, social science, and the humanities, as well as a format for developing problem-solving skills, familiarity with quantitative and qualitative analysis, historical and literary insight, and an understanding of the scientific method. Participation in research provides a foundation for professional competence and opportunities for learning-by-doing. Community interaction enables students to become familiar with their responsibilities, hone their leadership and communication skills, and gain self-mastery. Although each of the three components forms a distinct area of a student’s education, the contribution of each reinforces and adds to that of the others. To provide a uniquely excellent education, MIT brings students and faculty together to learn from one another through academics, research, and community.

Since then, MIT embarked on one of the most ambitious building initiatives in its history, aimed at creating a stronger campus community through enhanced residential options and the provision of advanced educational and research facilities. This initiative added nearly one million square feet of new facilities to the campus—smart residence halls and common spaces to inspire innovative collaborations, cutting-edge laboratories to support the emergence of new technologies, and visionary architecture to reinforce the intensity, curiosity, and excitement that are a defining value of the Institute, and of an MIT education.

The Institute has also moved to renovate and enhance its existing physical plant and infrastructure. Most institutional structures require renovation about every 30 years, with MIT buildings dating from the 1960s and 1970s in line for revitalization today. One recent example is the award-winning renovation of the Dreyfus Chemistry Building, a creation of I. M. Pei (March, 1940) that was dedicated in 1970. The building now contains state-of-the-art chemistry labs, enhanced safety and environmental systems, and a flexible space format that allows for reconfiguration as needs evolve. Another area of dramatic change is the transformation of the Vassar Streetscape, which turned a nondescript urban byway into a central campus boulevard unifying the physical and aesthetic connections among MIT’s buildings and public spaces. Most recently, the renovation of Fariborz Maseeh Hall allows MIT to increase its undergraduate study body by about 250 students.

MIT’s building program, both in its broad outlines and specific details, reflects the Institute’s commitment to removing boundaries between life and learning, inspiring freedom of imagination, and reinventing the substance of education in the 21st century.

### Students and Faculty

MIT enrolled 10,894 students in 2011–2012, including 4,384 undergraduates and 6,510 graduate students. These MIT students came from all 50 states, the District of Columbia, three territories, and 115 foreign countries. Nearly 10 percent of the undergraduates and 38 percent of the graduate students were international.

In the same year, there were 1,018 faculty members in MIT’s professorial ranks, including 217 women. The total teaching staff numbered 1,738. Most faculty members at MIT teach both undergraduate and graduate students. Undergraduates frequently register for graduate classes, and many undergraduates and graduate students participate, often together, in advanced research.

The confluence of ages, disciplines, and nationalities so characteristic of MIT brings together students and teachers, biologists and architects, humanists and engineers, young and old, and deeply influences the life and experience of every member of the academic community. The result is an academic environment with a strong focus on excellence and a diverse range of interests.
The Campus

MIT's 154-acre campus extends for more than a mile along the Cambridge side of the Charles River Basin facing historic Beacon Hill and the central sections of Boston. Many academic activities occur within 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 an integral part of the campus, as are the recreational buildings, dormitories, and dining halls. This arrangement contributes greatly to the sense of unity and community involvement that characterizes the Institute.

At the eastern end of the campus is an array of buildings for studies in management, economics, international studies, and political science, including Building E62, the new home of the MIT Sloan School of Management. The 215,000-square-foot building with a 190,000-square-foot underground garage was designed by Moore Ruble Yudell Architects & Planners and Bruner/Cott Architects and opened in June 2010. The building is one of the most sustainable on campus and received LEED Gold Certification in 2011. An indoor corridor connects to the Alfred P. Sloan Building. Next to them is the Grover M. Hermann Building that houses the Dewey Library for Management and Social Sciences. The nearby Arthur D. Little Building, which also connects to Building E62, underwent a major renovation in 2011. Adjacent to these academic buildings is Eastgate, a 29-story student family apartment tower.

Also located on the east end of the campus are buildings housing the MIT-Harvard Division of Health Sciences and Technology and MIT Medical's Health Services Center. The Health Services Center provides a pharmacy and facilities for medical, dental, surgical, and other specialties.

Adjacent to the Health Services Center is I. M. Pei's Wiesner Building, housing the Media Laboratory, the Office of the Arts, and the Albert and Vera List Visual Arts Center, comprising three exhibition galleries and a film/video theater. In fall 2009, a new building opened that nearly doubles the space for the Media Lab and School of Architecture and Planning. The 163,000-square-foot extension was designed by a team headed by Pritzker Prize–winning architect Fumihiko Maki and executive architects Leers Weinzapfel Associates. The new building links to the Wiesner Building through a multi-tiered central atrium flanked by nine fully visible laboratories, allowing the researchers in both buildings to interact easily.

A commanding feature of the East Campus is McDermott Court, featuring a great sculpture by Alexander Calder that rises in bold contrast to the facade of the 20-story Center for Earth Sciences (Cecil and Ida Green Building). Besides the Calder, MIT's outstanding collection of contemporary environmental sculpture includes works by Henry Moore, Louise Nevelson, Pablo Picasso, and Tony Smith.

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

The most significant expansion of the main group of campus buildings since the 1930s was completed in fall 2007. The cornerstone of the project is the Green Center, named for Cecil and Ida Green, whose leadership gift for Physics initiated a major renovation of the historic Bosworth Buildings by providing significant infrastructure renewal and modernization.

Interconnected with these central buildings are the Center for Life Sciences (the Dorrance and the Whitaker buildings), the Karl Taylor Compton Laboratories (for electronics and nuclear science), the EG&G Education Center (with lecture and laboratory facilities for the Department of Electrical Engineering and Computer Science), the Center for Materials Science and Engineering (the Vannevar Bush Building), the Sloan Laboratory, the Guggenheim Laboratory, and the Center for Advanced Engineering Study.

An outdoor area known as North Court sits adjacent to several cafés and features benches and tables for eating outside. The area has pathways leading to several buildings, including the Koch Biology Building and the new home of the Koch Institute for Integrative Cancer Research at MIT. Building 76 was completed in December 2010 and received LEED Gold Certification in 2011. The building is located on Main Street across from the Broad and Whitehead institutes. The 360,000-square-foot building was designed by Ellenzweig of Cambridge, MA.

Next to the Koch Institute is the Ray and Maria Stata Center for Computer, Information, and Intelligence Sciences, designed by Frank O. Gehry—a cluster of irregular shapes wrapped around a central meeting area. The Stata Center was created to foster the kinds of creative collaborations that can arise when curious, talented individuals and teams are brought together in the right environment. It is the home of the Computer Science and Artificial Intelligence Laboratory, the Laboratory for Information and Decision Systems, and the Department of Linguistics and Philosophy.

Across Vassar Street from the Stata Center are facilities for the brain and cognitive sciences. Dedicated in fall 2005, the 411,000-square-foot...
improvements were made, enhancing activities on Roberts Field. In summer 2008, a new synthetic turf was installed and lighting inside the track oval for intercollegiate football, soccer, lacrosse, and field facilities for the steeplechase and other field events, with a game field track, the first of its kind in North America. The stadium also includes Steinbrenner Stadium includes a six-lane, 400-meter, all-weather running tracks connected by a grid of anodized aluminum. As a result, the building reflects light during the day and glows with interior light after dark. Photo by Andy Ryan.

These athletic facilities are complemented by the impressive Albert and Barrie Zesiger Sports and Fitness Center, designed by Pritzker Prize–winning architect Kevin Roche, John Dinkeloo & Associates, and Sasaki Associates. This luminous complex contains an Olympic-class 50-meter pool, seating for 450 spectators, a training pool, an 11,000-square-foot fitness center, and six squash courts built to international competition standards.

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

At the intersection of Massachusetts Avenue and Memorial Drive is Fariborz Maseeh Hall. The dormitory formerly known as both W1 and Ashdown House was renamed in recognition of a $24 million gift from MIT alumnus Fariborz Maseeh and the Massiah Foundation. This transformational investment allows MIT to expand the undergraduate student body to 4,500 students, an increase of about 250 from recent enrollment figures. The building opened in August of 2011 after receiving an extensive renovation.

Lining Memorial Drive and facing the Charles River are additional student residences, among them the serpentine Baker House, designed by the Finnish architect Alvar Aalto and internationally recognized as a masterpiece of modernism. Renovated in conjunction with its 50th anniversary, Baker House is one of the most popular dormitories at the Institute, in part because of the extraordinary residential experience it provides. Down the road from Baker House at the end of Amherst Alley is the Westgate apartment complex for students with families and the Tang Residence Hall for graduate students.

Simmons Hall, an undergraduate dormitory on Vassar Street, was created by architect Steven Holl in collaboration with Perry Dean Rogers and Partners and acclaimed for the inventive ways it opens to the community. The Warehouse, a residential complex developed from a renovated industrial warehouse built in 1890, offers graduate students an attractive alternative to off-campus housing. The Sidney-Pacific Street graduate residence offers recreational and retail services at street level, giving the building a lively neighborhood presence. Added to the graduate community in fall 2008 is a 275,000-square-foot complex that includes 550 beds, a dining hall, and the Thirsty Ear Pub. The complex is located next to the Sidney-Pacific residence hall and is named Ashdown House after Avery Ashdown, the late housemaster for Building W1, the former home of the graduate students who now live in the new building. Ashdown House is the first LEED Gold-certified building on campus. It was awarded that distinction for optimizing a sustainable design, using nontoxic materials, and incorporating innovative sustainable solutions.

The Boston and Cambridge Environment
MIT is in Cambridge, Massachusetts, on the north bank of the Charles River, facing the city of Boston. The city of Cambridge, well known as the residence of MIT and Harvard, is home to many students and professionals. More than one-fourth of its residents are students, and one out of every six jobs is in higher education.

Cambridge is a city of 13 areas, ranging from approximately 830 to 13,000 residents. Only five cities in the United States with a population
Infinite Corridor
The Infinite Corridor, one of the main thoroughfares at the Institute, runs a distance of 825 feet, or 251 meters, between Building 7 (the Massachusetts Avenue entrance to MIT) and Building 8, opening onto Eastman Court. Nearly the length of three football fields, the corridor is 9 feet wide and 16 feet high along its principal length.

This layout allows the corridor to capture the setting sun at a particular moment, creating a solar phenomenon sometimes called “MIThenge.” As viewed from a stationary point on the earth, the path of the sun through the sky traces a circle (roughly) that moves north and south as the seasons go by. In mid-November and in late January every year, the circular path crosses the axis of the Infinite Corridor. When this occurs, given favorable weather conditions, a shaft of sunlight is thrown the entire length of the corridor. The same cannot be seen at sunrise because the other end of the Infinite Corridor is blocked by Building 18. The best viewing of the phenomenon occurs at the third-floor level, which has fewer obstructions and less traffic. For more information, see the "Infinite Corridor Astronomy" at http://web.mit.edu/mithenge/.

Over 75,000 are more densely populated. The city’s diverse ethnicity is reflected in its black, Hispanic, Asian, American Indian, and white residents.

Within a two-mile radius of MIT are Boston’s Museum of Science and Museum of Fine Arts, the Isabella Stewart Gardner Museum, the New England Conservatory of Music, Symphony Hall, the New England Aquarium, and the Boston Public Library, as well as Fenway Park and TD Garden for professional baseball, basketball, and concerts. Students can also travel easily to Boston’s theater district, where Broadway plays are previewed and local productions are staged.

Among the cultural organizations enriching life 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, Boston University’s Huntington Theatre Company, the Loeb Drama Center, and the American Repertory Theatre.

MIT is one of more than 50 schools located in the Boston area, including Boston College, Boston University, Brandeis University, Harvard University, Lesley University, Northeastern University, Simmons College, Tufts University, Wellesley College, and many specialized professional art and music schools. The concentration of academic, cultural, and intellectual activity in this area is one of the most significant in the country.

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

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

Each of the academic departments and units listed below offers one or more degree-granting programs, as described in Parts 2 and 3 of this Bulletin. More detailed information can be obtained from the program and department offices.

School of Architecture and Planning
Architecture
Media Arts and Sciences
Urban Studies and Planning

School of Engineering
Aeronautics and Astronautics
Biological Engineering
Chemical Engineering
Civil and Environmental Engineering
Electrical Engineering and Computer Science
Engineering Systems
Materials Science and Engineering
Mechanical Engineering
Nuclear Science and Engineering
Institute for Medical Engineering and Science

School of Humanities, Arts, and Social Sciences
Anthropology
Comparative Media Studies
Economics
Foreign Languages and Literatures
History
Humanities
Linguistics and Philosophy
Literature
Music and Theater Arts
Political Science
Science, Technology, and Society
Writing and Humanistic Studies

Sloan School of Management
Management

School of Science
Biology
Brain and Cognitive Sciences
Chemistry
Earth, Atmospheric, and Planetary Sciences
Mathematics
Physics

Joint Program with Woods Hole Oceanographic Institution

The undergraduate academic program is based on a core of General Institute Requirements and on the specific curricula offered by departments for undergraduate majors. All undergraduate Courses at MIT lead to the Bachelor of Science (SB) degree. For most undergraduates, degree-granting programs require four years of full-time study.

Graduate degrees include Master of Architecture (MArch), Master of Science (SM), Master of Engineering (MEng), Master in City Planning (MCP), Master of Business Administration (MBA), Master of Finance (MFin), Engineer, Doctor of Philosophy (PhD), and Doctor of Science (ScD). Graduate students may also take advantage of a number of standing interdisciplinary programs (as described under Interdisciplinary Graduate Programs in Part 3) or develop individually tailored programs in consultation with the faculty.

Engineer degrees include Civil Engineer (CE), Electrical Engineer (EE), Engineer in Aeronautics and Astronautics (EAA), Engineer in Computer Science (ECS), Environmental Engineer (EnvE), Materials Engineer (MatE), Mechanical Engineer (MechE), Naval Engineer (NavE), Nuclear Engineer (NuclE), and Ocean Engineer (OceanE).

Accreditation
MIT is accredited by the New England Association of Schools and Colleges, Inc., through its Commission on Institutions of Higher Education. Inquiries regarding MIT's accreditation status should be directed to the Office of the Vice President and Secretary of the Corporation, Massachusetts Institute of Technology. Individuals may also contact:

Commission on Institutions of Higher Education
New England Association of Schools and Colleges
209 Burlington Road, Suite 201
Bedford, MA 01730-1433
telephone 781-271-0022
email cihe@neasc.org.

Many degree programs at MIT are accredited by specialized professional accrediting bodies, including the Association to Advance Collegiate Schools of Business, the Accreditation Board for Engineering and Technology, the American Chemical Society, the American Institute of Chemical Engineers, the Computer Science Accreditation Board, the National Architectural Accrediting Board, and the Planning Accreditation Board. Academic departments can provide information on the accreditation of the specific degree programs they offer.

ADMINISTRATION

MIT Corporation
The Institute's board of trustees is known as the Corporation, led by its chairman. Its membership includes approximately 75 distinguished leaders in science, engineering, industry, education, and public service, and (as ex officio members) the chairman, president, executive vice president and treasurer, and secretary of the Corporation. Between quarterly meetings, the Corporation functions through its officers and executive committee. For more information, visit the website at http://web.mit.edu/corporation/.

The Corporation appoints visiting committees for each academic department and for certain of the other major activities at the Institute that relate to the undergraduate student experience. These committees, whose members are leaders in their respective professions, make recommendations to the Institute administration and the Corporation concerning departmental activities and, in turn, provide counsel to the departments.

Academic and Administrative Organization
The Institute's chief executive officer is the president. Senior academic and administrative officers of the Institute include the chancellor, provost, executive vice president and treasurer, associate provosts, deans of the schools, vice presidents, dean for graduate education, dean for undergraduate education, dean for student life, and director of the MIT Libraries.

The Institute's academic departments and divisions—each under the leadership of a head, director, or associate dean—are organized within five schools. In addition, numerous interdisciplinary laboratories and centers have been organized to facilitate research in fields that extend across traditional boundaries; administration of each laboratory or center is the responsibility of the faculty member who serves as its director. Research
projects sponsored by government, industry, or foundations are administered through the Office of Sponsored Programs.

Educational policy for the Institute is determined by the MIT Faculty (referring to those members of the faculty and administration who have voting privileges as designated by the Rules and Regulations of the Faculty). The Faculty meets monthly during the academic year and conducts much of its business through a number of elected standing committees. The Faculty Policy Committee (FPC), which includes student members, maintains a broad overview of the Institute’s academic programs, deals with a wide range of policy issues of concern to the Faculty, and coordinates the work of the Faculty committees. The chair of the Faculty chairs the FPC.

Communication and exchange within and between the faculty and the administration are facilitated through four Institute-wide councils. Senior officers responsible for the overall administration of the Institute, plus the chair of the Faculty, meet regularly as the Academic Council to confer on matters of Institute policy. Department heads and directors of major laboratories and centers join them to form the Faculty Council, which meets as needed. The Administrative Council, comprised of the heads of the major administrative sections of the Institute, meets twice during the academic year. The Creative Arts Council, chaired by an associate provost, consists of deans, department heads, directors in the arts, and campus-wide faculty representatives who meet to confer on issues concerning arts programs and policy.

For a detailed view of MIT’s organizational structure, see http://orgchart.mit.edu/.

**ALUMNI**

**MIT Alumni Association**

The MIT Alumni Association, founded by alumni in 1875, provides multiple ways for the Institute’s 125,200 former students to stay in touch with one another and maintain their connections to the Institute. Under the direction of a volunteer alumni board, the Association staff helps alumni organize events, communicate with one another, and raise funds for MIT.

In addition to programs such as regional clubs and reunions, the Association offers an opportunity for alumni to make a virtual “infinite connection” to the MIT community at http://alum.mit.edu/. More than 80,000 alumni members have made that connection and are using Email Forwarding for Life, the online alumni directory, alumni email lists, online mentoring services, events registration, and online Alumni Fund giving. Social networking sites such as LinkedIn, Facebook, Twitter, and the Slice of MIT blog are also very popular. More than 11,000 alumni volunteer their services for MIT each year, with many serving as class and club officers, educational counselors, and members of the MIT Corporation and its visiting committees. Other popular alumni programs include View from the Top, Tech Reunions, and Toast to IAP.

In fiscal year 2011, the Alumni Fund reported $52.4 million in gifts, contributed by 41,390 alumni donors, students, parents, and friends.
Life at MIT is anything but dull. But inquiring minds still need to know. Are there fraternities and sororities at MIT? What about the performing arts? Where are the dining services? Is child care available? How much does health care coverage cost? Come back to this section for these topics and more.

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ACTIVITIES

There is much more to an MIT education than just study and research in classrooms and laboratories. Numerous activities and services are available that complement academic pursuits and provide opportunities for students to grow and develop new interests and lifelong hobbies. This section describes just a few of the activities that define campus life.

There are more than 400 co-curricular student organizations at MIT (many open to both faculty and students), including the Outing Club, the Solar Electric Vehicle Team, the Debate Team, the FM local broadcasting station (WMBR), the MIT Society for Women Engineers, the Student Art Association, Model UN, Circle K, the Black Students’ Union, the Latino Cultural Center, the Asian American Association, and the South Asian American Students Association.

Many students are actively engaged in service work either through the Public Service Center or on their own. Groups such as the Intrafraternity Council and Alpha Phi Omega, the national service fraternity, Share a Vital Earth, and the Educational Studies Program sponsor active social service programs. For example, the Educational Studies Program provides opportunities for MIT students to work with area high school students.

MIT also has a number of cultural and identity groups. Over 30 international student groups sponsor a rich array of programs, including discussion groups and social events. The International Students’ Association sponsors a newsletter, assemblies, and other events. MIT has an active organization of Gays, Lesbians, Bisexuals and Friends at MIT (GAMIT), which organizes weekly awareness programs and discussion groups and sponsors social events throughout the year. The Technology Community Women (TCW) is composed of spouses of MIT students, undergraduate as well as graduate, and sponsors monthly programs as a social and service organization. Other interest groups focus on bridge, chess, ham radio, and strategic games.

For more information, contact the Association of Student Activities, Room W20-401, see the ASA website at http://web.mit.edu/asa/www/, or contact the Student Activities Office, Room W20-549, 617-253-6777, or visit http://studentlife.mit.edu/sao/.

ADvising and Support

The Institute offers a variety of resources for advising and personal support. By intention, they are not centralized in one place. Students are free to choose the resource that appears to be most helpful, and support is available in many forms, including walk-in conversations as well as scheduled appointments, and with goals ranging from information dissemination to skilled psychotherapy.

All students have an academic advisor. The Office of Undergraduate Advising and Academic Programming assigns advisors to freshmen. Academic departments assign faculty advisors to students who have declared a major. In addition, there are faculty undergraduate and graduate officers in each academic department, as well as academic administrators who consult with students about their academic programs.

Student Support Services (SS; http://web.mit.edu/uaap/53/) in the Office of Undergraduate Advising and Academic Programming, offers support and advice to all students, whether the situation is academic, personal, or both. In addition to providing support, SS deans assist students who cannot meet academic obligations for personal or medical reasons, assist in the processing of OX grades, process withdrawals and readmissions to the Institute, and advocate on behalf of students. SS also works closely with other offices in supporting the diverse student population.

At MIT Medical (http://medweb.mit.edu/), the Mental Health and Counseling Service provides individual and group counseling for a broad array of problems and concerns. The staff are most helpful with such issues as test anxiety, lonesomeness, problems with making and keeping friends and relationships, drinking and using substances, and worry. In addition, Community Wellness at MIT Medical runs seminars ranging from stress management and smoking cessation to weight control and nutrition education. For more information, call 617-253-2916.

Several campus offices specialize in particular areas, such as Student Financial Services (including student employment), the religious counselors, Global Education and Career Development (which also offers prehealth advising), and the Office of Undergraduate Advising and Academic Programming. The Campus Police can also be helpful to students in many ways.

Arts at MIT

The arts are a fundamental component of MIT’s core curriculum and community, reflecting and enhancing the Institute’s creativity, innovation, and excellence while advancing the self-discovery, problem solving, and collaborative skills needed by leaders meeting the challenges of the 21st century.

More than half of all MIT undergraduates enroll in arts courses each year—over a third of them in music classes—and many major or minor in arts-related subjects. MIT’s arts faculty includes eminent artists such as Pulitzer Prize recipients composer John Harbison and writer Junot Díaz, as well as composer and musician Evan Ziporyn and visual artist Renée Green.

Each year MIT’s performing groups and outside artists present over 300 music, theater, and dance events. Productions range from chamber music to electronic “hyperinstruments,” and from Shakespearean plays to science theater. MIT’s world music program features Boston’s only Balinese gamelan, a Senegalese drumming ensemble, and an acclaimed South Asian performance series. For more information about the arts at MIT, visit http://arts.mit.edu/.

Art, Culture and Technology

The Department of Architecture’s Program in Art, Culture, and Technology (ACT) operates as a critical production- and education-based laboratory focusing on artistic research, advanced visual studies, and transdisciplinary collaboration within the context of MIT’s technological community. Its weekly lecture series is open to the public. For information on its events and undergraduate and graduate academic programs, visit http://act.mit.edu/.

Dance

Extracurricular dance activities at MIT are sponsored by the Folk Dance Club, Tech Squares, Ballroom Dancing Club, Dance Troupe, and various international student groups, providing regular opportunities for dancers at all levels of ability. Access their websites via http://theaterarts.mit.edu/.
Literary Arts
MIT’s Program in Writing and Humanistic Studies offers courses in fiction, nonfiction prose, poetry, science writing, and digital media, taught by award-winning faculty. The Writers Series, Poetry@MIT series, and the Visiting Artists Program frequently present readings and lectures by renowned writers. For more information, call 617-253-7894 or visit http://writing.mit.edu/. The Literature Section maintains a level of excellence and innovation as it remains responsive to MIT’s distinctive intellectual environment. Its Pleasures in Poetry session meets each weekday during IAP, bringing together faculty, staff, students, and others from the community who share a love of poetry. It also sponsors readings by visiting authors which are open to the MIT community as well as the public. Literature, along with the MIT Libraries, sponsors the MIT Literary Society, an undergraduate reading group that focuses on literary discussion outside the classroom. Students may contribute their own writings to a variety of campus publications, as well as compete for annual writing prizes awarded in several categories. For more information, call 617-253-7894 or visit http://lit.mit.edu/.

Media Arts
An international leader in the development of innovative digital media and information technologies, MIT’s Media Lab is a uniquely flexible organization where faculty members, research staff, and students from numerous, seemingly unrelated disciplines work together “atelier style,” doing the things that conventional wisdom says can’t or shouldn’t be done. The goal is to develop technologies and concepts that foster creativity—empowering people of all ages, from all walks of life, in all societies, to design and invent new possibilities for themselves and the communities around them.

Researchers in the Media Lab, with backgrounds ranging from computer science to psychology, music to graphic design, and architecture to mechanical engineering, see a future where machines not only augment human capabilities, but also relate to people on more “human” terms—a future where our devices not only respond to commands, but also understand them. Research opportunities for students are available through the Program in Media Arts and Sciences, based in MIT’s School of Architecture and Planning, and through the Undergraduate Research Opportunities Program. For more information, visit http://media.mit.edu/.

The Comparative Media Studies (CMS) program is committed to the art of thinking across media forms, theoretical domains, cultural contexts, and historical periods. The program encourages the bridging of theory and practice, as much through course work as through participation in faculty and independent research projects. CMS subjects are designed to teach students to both make and reflect upon media, and in the process to acquire important skills in teamwork, leadership, problem solving, collaboration, brainstorming, communications, and project completion, which will prepare them for a broad range of academic and professional careers. For more information, visit http://cms.mit.edu/.

Music
MIT’s music faculty includes internationally acclaimed composers, performers, and musicologists. Students can choose to pursue a full or joint major, a minor, or a HASS concentration in music. They can also take private lessons with financial support from the Emerson scholar-ship program; music subjects in theory, composition, history, jazz and world music; or participate (for credit or not) in faculty-led performance ensembles. These include the MIT Symphony Orchestra, Wind Ensemble, Festival Jazz Ensemble, Chamber Music Society, Concert Choir, Chamber Chorus, Balinese Gamelan Galak-Tika, and Rambax MIT (a Senegalese drumming ensemble). In addition to ensemble performances and student recitals, concerts are also presented as part of the MIT Faculty, Affiliated Artists, Guest Artists, and MITHAS. Artists of national and international stature frequently come to perform at MIT and to interact with students in and out of the classroom. For more information call 617-253-3210, or email mta-request@mit.edu. In addition to the performance opportunities offered by the music program within the School of Humanities, Arts, and Social Sciences, there are many student-directed ensembles and a capella groups that perform on campus as well. Visit http://arts.mit.edu/academic/music/.

Theater
MIT’s programs in Theater Arts afford opportunities for serious study and training in acting, directing, playwriting, dramaturgy, stagecraft, and design. Classes are small, and students work directly with renowned faculty and guest artists, or initiate independent student workshop productions. Students may choose a minor or HASS concentration in theater; it is also possible to create an individually tailored theater major. A wide variety of theatrical performances are presented by MIT Dramashop and Dance Theater Ensemble, the co-curricular student-producing group of MIT Theater Arts. These productions, directed by professionals in their fields, often offer interested students opportunities to further develop their work in professional settings. Extracurricular student organizations such as Shakespeare Ensemble, Musical Theatre Guild, Gilbert & Sullivan Players, and the improv group Roadkill Buffet offer additional performance and production experience.

An annual Theater Arts Open House on Registration Day in early September allows students to meet the people who produce theater events and to learn more about opportunities to get involved in various productions. For more information, call 617-253-2877, or visit http://arts.mit.edu/academic/theater-arts/.

Visual Arts
From large-scale public art to film and photography, the visual arts are celebrated in innovative ways at MIT. Excellent opportunities exist for members of the MIT community to view and create art in a variety of media (see List Visual Arts Center, MIT Museum, and Student Art Association below). The Program in Art Culture and Technology offers undergraduate classes in public, installation, and media arts, and has a prominent master’s program (see ACT above). MIT students can take classes in traditional fine arts at Harvard, the Massachusetts College of Art and Design, the School of the Museum of Fine Arts, and Wellesley College through cross-registration programs (see http://arts.mit.edu/academic/cross-registration/).

Visiting Artists Program
A flourishing Visiting Artists Program complements the curriculum, allowing students to engage with distinguished visiting artists, including architect/engineer/artist Santiago Calatrava, sound artist Florian Hecker,
innovative music ensemble Bang on a Can All-Stars, visual artist Trevor Paglen, and jazz pianist Jason Moran. For more information, visit http://arts.mit.edu/va/.

The Eugene McDermott Award in the Arts at MIT (http://arts.mit.edu/mcdermott) recognizes rising, innovative talents and offers its recipients a $100,000 cash prize and campus residency. Past recipients include composer Tan Dun, video artist Bill Viola, conductor Gustavo Dudamel, and multidisciplinary performance and media artist Robert Lepage.

List Visual Arts Center
Just as MIT pushes the frontiers of scientific and intellectual inquiry, the mission of the List Visual Arts Center is to explore contemporary art in all media. Each year, the center presents a challenging exhibition program that looks beyond art’s traditional aesthetic functions to examine the cultural, social, political, scientific, or economic contexts that inform the work. Exhibitions are presented in three galleries on the first floor of the I. M. Pei–designed Wiesner Building (Building E15) and the Dean’s Gallery in the Sloan School (Building E6o). All are free and open to the public. Nationally distributed catalogs, artist talks, gallery tours, and symposia accompany the exhibitions.

The List Center also manages MIT’s permanent collection of artworks, including a student loan art program of approximately 500 works that enables students to borrow original pieces of art, such as prints and photographs, for up to a year, and a sizable collection of paintings, sculpture, drawings, prints, and photos sited throughout the MIT campus.

For more information about the List Center’s exhibitions and programs, visit http://listart.mit.edu/.

MIT Museum
The MIT Museum’s broad range of exhibitions and programs for children and adults provides unique public access to what the Institute has always done best: the application of innovative research to the solution of real-world problems. On a yearly basis, over 100,000 people visit the museum and its galleries.

The Innovation Gallery features interactive displays from a variety of research labs at MIT and a popular program space that complements exhibitions on the history of MIT, artificial intelligence, holography and spatial imaging, and the kinetic sculptures of Arthur Ganson.

In addition to the main collection at 265 Massachusetts Avenue, the MIT Museum oversees the Hart Nautical Gallery in Building 5 and the Compton Gallery in Building 10. The museum also sponsors the Cambridge Science Festival, now in its sixth year, which attracts 50,000 visitors each spring. For more information about the museum’s exhibitions and programs, visit http://web.mit.edu/museum/.

Office of the Arts
The Office of the Arts oversees, coordinates, supports, and facilitates arts activities under the direction of the executive director of arts initiatives. The office’s branches include the Council for the Arts, Student Programs, Visiting Artists Program, and Arts Communications. For general information on arts programs and activities at MIT, visit http://arts.mit.edu/ and see the arts calendar at http://arts.mit.edu/events/.

Council for the Arts at MIT
The council is a volunteer group of alumni and friends established in 1972 by MIT president Jerome B. Wiesner to support the visual, literary, and performing arts. The Council for the Arts recognizes distinguished artists from all disciplines with one of the country’s most esteemed arts prizes, the Eugene McDermott Award in the Arts at MIT. In addition, the council, since its inception, has awarded over 2,300 individual grants and administers annual student prizes in the arts, including the Sudler Prize, the Laya and Jerome B. Wiesner Student Art Awards, and the Harold and Arlene Schnitzer Prize in the Visual Arts (see http://arts.mit.edu/about/council/awards-prizes/). Council programs directly benefit MIT students by providing free tickets to the Boston Symphony Orchestra, Boston Chamber Music Society, and Boston Modern Orchestra Project, as well as free admission to Boston’s Museum of Fine Arts, the Photographic Resource Center, the Harvard Art Museum, the Institute of Contemporary Art/Boston, the Isabella Stewart Gardner Museum, and a number of performances and concerts throughout the year.

The Council for the Arts’ Grants Program encourages the dreams and talents of the MIT community, providing the opportunity for students, faculty, and staff to apply for funding for arts projects in all disciplines. Grants range from a few hundred to several thousand dollars. For more information, visit http://arts.mit.edu/about/council/camit-grants/.

Student Programs
Several programs encourage students to engage in the arts. Freshman seminars led by MIT faculty and staff introduce participants to the many academic and performance programs in the arts at MIT and the Boston area. Arts Scholars is an honors program that enables students who are active in the arts to attend exhibitions, plays, and concerts with experts in the respective arts disciplines (see http://arts.mit.edu/participate/arts-scholars/). The Grad Arts Forum encourages interdisciplinary communication among graduate students through a series of presentations and informal discussions of artistic work by grad students (http://arts.mit.edu/participate/grad-arts-forum/). Student Programs also administers the annual mural competition for currently enrolled MIT students.

Student Art Association
The Student Art Association offers noncredit classes and facilities for many visual arts activities including animation, ceramics, photography, painting, and drawing. For more information, visit http://saa.mit.edu/.

ATHLETICS
Athletics and recreation are an important part of campus life for many students at MIT, and the Institute encourages everyone to participate in some type of athletic activity.

The Institute supports a broad intercollegiate athletic program offering 33 varsity sports. While the Engineers’ rowing programs compete at the Division I level, MIT’s primary league affiliation lies with the New England Women’s and Men’s Athletic Conference (NEWMAC) as a Division III member of the NCAA. Although crew is the only classified Division I program,
water polo, sailing, rifle, track and field, squash, cross country, fencing, and men’s volleyball all compete against Division I opponents.

MIT features one of the nation’s most expansive club programs, with over 900 participants and 35 teams, a third of which are martial arts clubs. All club teams are led and organized by MIT students and are governed by the student-led Club Sports Council. The Institute places all of its club programs into two categories: instructional and competitive. Instructional clubs offer formal training under the supervision of professional instructors, while competitive clubs compete in regional and national-level tournaments, with many ranking in the nation’s top 10. The most successful clubs at MIT include sport taekwondo, women’s water polo, women’s ultimate frisbee, rugby, and cycling.

The MIT intramural sports program offers competition in 19 sports, with participation of more than 4,000 students and faculty. Ultimate frisbee, soccer, and badminton are among the most competitive and popular activities.

MIT’s athletic complex, with its 10 buildings and 26 acres of playing fields, is one of the most expansive in New England. Steinbrenner Stadium, one of the nation’s finest track and field facilities, contains the recently renovated Roberts Field, which features a new FieldTurf artificial playing surface and lights; the Johnson Athletic Center houses an indoor track and ice rink. Recent enhancements include a new bubble and reconstruction of four indoor courts at the J.B. Carr Tennis Center and the installation of two saunas. The duPont Athletic Center is equipped with a pistol and rifle range, fencing room, wrestling room, squash courts, the Rudovsky Indoor Golf Range, and additional instructional rooms for dance and martial arts. The Zesiger Sports and Fitness Center features two swimming pools, a fitness center, international-scale squash courts, and a multiactivity court. The Stata Center is home to the Alumni Pool and the Wang Fitness Center. MIT’s athletic facilities extend to the Charles River with the Wood Sailing Pavilion and the Pierce Boathouse.

For information on MIT’s Physical Education Requirement, see Undergraduate Education in Part 1; for more information on MIT’s athletic programs, visit http://www.mitathletics.com/.

**CAMPUS DINING**

MIT Campus Dining venues are located across the campus, providing a broad range of diverse and healthy options prepared from fresh quality ingredients. MIT offers comprehensive traditional meal plans through its House Dining operations, as well as a declining balance account and TechCASH, which can be used to purchase meals in any campus dining facility. TechCASH is MIT’s universal debit account that can be used for all campus services, including food purchases. Many retail locations also accept credit and debit cards.

The Meal Plan Program ranges from a full 19 meals/week to 7 meals/week (the Any 7 plan is only available to students in the class of 2013 residing in Baker House, McCormick Hall, Next House, and Simmons Hall). All MIT students are eligible to participate in the House Dining Meal Plan at varying levels depending upon their place of residence and class year (see http://dining.mit.edu/meal-plans/ for details). Student residents of Baker House, Maseeh Hall, McCormick Hall, Next House, and Simmons Hall are required to enroll in a House Dining Meal Plan. All students are encouraged to consider their meal plan options when choosing their housing preferences. House Dining Rooms, like all Campus Dining operations, are open to the entire MIT community. Details on all Campus Dining services, including locations, menus, hours of operation, nutrition and special diets, as well as meal plan options can be found at http://dining.mit.edu/. Students with special dietary needs are encouraged to contact MIT Campus Dining at 617-253-4875 or foodstuff@mit.edu with questions. Confidential consultations with MIT Medical and House Dining dieticians are also available.

**CAMPUS MEDIA**

Student publications at MIT include The Tech, a student newspaper published twice weekly; Technique, the senior yearbook; Voo Doo, an occasional humor magazine; and The Graduate Student News, a publication of the Graduate Student Council. Students may also contribute their talents to house newspapers and to a variety of departmental and organizational newsletters.

On the air, WMBR is MIT’s commercial-free radio station operating under a license held by the Technology Broadcasting Corporation, and MIT Student Cable Television broadcasts original and syndicated programming 24 hours per day.

**MIT Press**

The MIT Press (http://mitpress.mit.edu/) is one of the largest and most respected university presses in the world. It is a major publishing presence in diverse fields, including art and architecture; cognitive science; computer science; economics; environmental studies; game studies; life sciences; linguistics; neuroscience; new media; philosophy; and science, technology, and society. The Press publishes journals, scholarly monographs, trade books, textbooks, and reference works, in print and electronic formats.

MIT Press authors are drawn from the worldwide academic community. The Press is known for its work in emerging fields of scholarship, for its strong international distribution, and for pioneering projects such as CogNet (http://cognet.mit.edu/), an online resource for the cognitive sciences. The Press operates the MIT Press Bookstore at 292 Main Street in Kendall Square (http://mitpress.mit.edu/bookstore/).

**CAMPUS PARKING**

Parking facilities at MIT are extremely limited. Students are advised to avoid bringing an automobile to MIT if possible. In general, the Institute cannot provide parking for freshmen. Students may obtain information about parking on campus and request a parking permit on the MIT Parking and Transportation Office website, http://web.mit.edu/facilities/transportation/parking/student/index.html. Students with disabilities who have parking requests should see the Medical Department or Student Disabilities Services for approval.

Students who plan to bring motor vehicles to Cambridge should take careful note of the information regarding pertinent Massachusetts laws...
C A M P U S  L I F E

distributed with registration material. In addition, since the rate of car thefts in this state is one of the highest in the nation, serious consideration should be given to equipping automobiles with anti-theft devices.

Information about parking and other transportation resources at MIT is available at http://web.mit.edu/facilities/transportation/ or at the MIT Parking and Transportation office, Room W20-022.

C H I L D  C A R E  A N D  P A R E N T I N G  R E S O U R C E S

The MIT Work-Life Center
The MIT Work-Life Center offers information on work/life issues including child care, children’s schooling, and parenting. The center’s comprehensive website offers listings and guidance on child care programs, schools, family issues, summer camps, and other local resources for parents and children. Child care costs are higher in Boston than in many other cities and space is limited; plan to begin your search early and to contact the center by phone or email for additional assistance or an individual consultation.

The center also offers resources on child development, balancing work and family, relocation to MIT, raising bilingual children, and many other issues. The office is located in Room 16-151, 617-253-1592, worklife@mit.edu, http://hrweb.mit.edu/worklife/.

Technology Children’s Centers
MIT’s child care centers, Technology Children’s Centers (TCC), provide year-round educational care to children from two months of age through kindergarten entry (approximately five years of age). TCC has four sites on campus and a fifth site near Lincoln Laboratory in Lexington, MA, approximately 10 miles west of campus. TCC’s campus centers, located at Eastgate, North Court, Stata, and Westgate, serve approximately 130 children; TCC at Lincoln Laboratory (LINC) serves an additional 110 children. TCC is managed by the MIT Work-Life Center, in partnership with Bright Horizons Family Solutions, a child care management company.

TCC offers priority enrollment to members of the MIT community. However, please be advised that there are long waiting lists for campus care for children in all age groups, and that incoming students are unlikely to secure a space for an infant or toddler on campus.

Information about services, tuition, and application forms are available at http://web.mit.edu/mitchildcare/.

For information about additional child care options, including Work-Life Resources 24/7, a child care referral service available to graduate students, visit the MIT Work-Life Center’s website at http://hrweb.mit.edu/worklife/.

MIT Day Camp
The MIT Day Camp is operated by the Athletic Department on weekdays from 9 am to 3:45 pm from mid-June through mid-August for children ages 6 to 13. An early drop-off starting at 8 am is available, and an extended sitting service is available until 5:30 pm. The nine-week program is divided into sessions, so that a child may be enrolled for a few weeks or for the entire summer.

Enrollment is limited. Visit http://web.mit.edu/daycamp/, or call the Day Camp Office at 617-253-2913 for additional information.


MIT recognizes 37 fraternities, sororities, and independent living groups (FSILGs). Of these, 23 are nationally affiliated fraternities and two are local. There are also six living groups, five of which are coed and one is for women only. All six sororities are nationally affiliated; five are residential.

Most groups live in houses owned by the respective organization’s house corporation located off campus in the Boston, Brookline, and Cambridge communities. The Interfraternity Council (IFC) acts as the governing body for the fraternities, the Panhellenic Association (Panhel) represents the sororities, and the Living Group Council (LGC) represents the living groups. In addition, there are several students affiliated with historically black and latino fraternities and sororities at MIT; these groups are part of city-wide charter organizations not advised by the FSILG Office.

The oldest fraternity on campus was founded at MIT in 1873. More than 44 percent of the undergraduate population is affiliated with a fraternity, sorority, or living group. FSILGs play an active role on campus, and members hold leadership positions in various clubs and organizations. FSILG members also take part in a number of intramural sports, as well as volunteer their time with many charitable and nonprofit organizations.

The espoused values of the FSILG Community are leadership, scholarship, citizenship, and service. Each organization is self-governing, manages all its operations and maintenance, and develops its own academic, social, membership, recreational, and external policies and programs. These organizations provide a unique experience in leadership, community planning, and group interactions.

Each residential fraternity, sorority, or living group has a live-in resident advisor. Resident advisors serve as mentors, guides, and resources for students and act as a liaison between the undergraduate chapter, the alumni, and MIT.

MIT students have opportunities to learn more about each of the fraternities, sororities, and living groups throughout the academic year. The formal recruitment period for fraternities and sororities is usually held in September. However, many fraternities and ILGs host recruitment events year round. In addition, incoming students receive information about the FSILGs at Orientation and Campus Preview Weekend programs. For more information about FSILGs, contact the Fraternity, Sorority, and Living Group Office in the Department of Residential Life and Dining, located in W59-200, 617-253-7546, FSILG-Office@mit.edu.

H O U S I N G

Undergraduate Housing
At the undergraduate level, MIT is essentially a residential university. Of the total undergraduate student body of 4,100, about 3,000 single men and women live in the 12 Institute residence halls on campus, and about 1,100 single men and women take advantage of living in MIT-approved fraternities, sororities, and independent living group residences. Transfer students may be able to obtain housing on a space-available basis after the Freshman Housing Lottery.
The residential system provides an environment conducive to personal development and academic achievement. The achievement of both goals relies greatly on individual initiative and responsibility, as well as on effective student governance in the residences. Students work with the professional staff in the offices of Residential Life Programs and Fraternities, Sororities, and Independent Living Groups to support and create conditions that enhance student learning and personal development.

Faculty families chosen for their understanding of and interest in students live in each of the Institute residence halls. They are not charged with formal academic or operational responsibilities; instead, they welcome informal associations with their residents. In all of the Institute residence halls, graduate resident tutors support the faculty residents in providing personal assistance to undergraduates.

With the exception of the all-female McCormick Hall, Institute residence halls have coeducational living facilities. Most of the coed residence halls also have single-gender living areas. Although first-year students are not guaranteed an assignment to a particular residence hall or single-gender area, every effort is made to assign students to one of their top choices.

Student governing groups establish and administer many residence hall regulations and maintain acceptable standards of community behavior. Residential student governments also organize social, athletic, and intellectual programs for residence hall members. In each Institute residence hall, a tax determined by the residents is collected by MIT and made available to the residence hall government to help support such activities. Individual fraternity, sorority, and independent living group chapters have similar charges to support their extracurricular programs.

The Institute believes that it is to the great advantage of all new students who do not live at home to reside on campus—that is, to live in a residence hall. First-year undergraduates particularly gain from associations with upperclass students and participation in residence programs. Therefore, all unmarried first-year undergraduates who cannot commute daily from their own homes or those of close relatives in the greater Boston area are required to live on campus. Exceptions to this requirement are made through a petition process reviewed by MIT Housing and the Office of the Dean for Student Life.

Institute Houses (Undergraduate)
- Everett Moore Baker House
- Bexley Hall
- Burton-Conner House
- East Campus Houses—Munroe, Hayden, Wood, Goodale, Bemis, and Walcott
- Frank S. MacGregor House
- Fariborz Maseeh Hall
- Stanley McCormick Hall
- New West Campus Houses—Ballard, Lawrence, Coolidge, Desmond, Fisk, and Thorn, which include Chocolate City, French House, German House, I-House, and Spanish House
- 500 Memorial Drive (Next House)
- Random Hall
- Senior House
- Simmons Hall

Rooms in the Institute houses are engaged for the full academic year. For 2012–2013 the rents for the houses will range from $2,982 to $4,275 per term.

A student who cancels a room assignment after the deadline of June 15 will be charged a cancellation fee. A student who withdraws from MIT during a regular term will receive a refund based on proration of the term rental over 15 weeks of occupancy.

Fraternities, Sororities, and Independent Living Groups
Undergraduates affiliated with a fraternity, sorority, or independent living group have the option of residing in the chapter house after their freshman year. Each FSILG has its own meal plan, many with chefs that cook for the entire chapter. In addition, members share responsibility for chapter house jobs and work closely with alumni and the FSILG office on the general maintenance and upkeep of the chapter facility. Room and board at FSILGs varies per term.

Additional Information
Additional information on undergraduate housing and application procedures is contained in The Guide to Residences. Each first-year student is sent a copy of this brochure about four months before registration day of the term for which he or she has been admitted to MIT. Others may request copies from the Undergraduate Housing Office, Room W59-200, 617-253-2811. Information about fraternities or sororities also may be obtained from the FSILG Office, Room W20-549, 617-253-7546 or at http://web.mit.edu/reslife/fsilg/.

Graduate Single Student Housing
Approximately 35 percent of MIT’s single graduate students reside on campus in Avery Allen Ashdown House, Ping Yuan Tang Residence Hall, Harold Edgerton House, The Warehouse (NW30), and Sidney-Pacific Residence Hall. Students must be registered each term (not including the summer) in order to reside in on-campus student housing. MIT attempts to house all new graduate students who desire to live on campus. New single student assignments are for one year. Returning students who receive housing through the Continuing Allocation Process may remain in housing continuously until they graduate, as long as they are registered each term. Students sign a new license agreement each year they are in residence.

These residence halls provide a rich living environment in a number of different formats, including suites, kitchen suites, and apartments. All of the buildings have active student governments that plan and facilitate social and cultural events. All of the buildings have a faculty member or faculty members in residence who, along with the house manager, support the students. All units are available as single sex. Coed two-bedroom apartments in Edgerton House and Tang Hall, two-bedroom suites and apartments in Sidney-Pacific, and two- and three-bedroom suites and apartments in Ashdown are available upon request. All buildings except for Edgerton House are furnished.

The rent for all graduate residences is charged on a monthly basis and the licenses are from the date of occupancy until August 15 each year. Graduate Housing’s strict termination policies can be found on its website. All rents include heat, hot water, electricity, internet, and basic cable, as
well as all building amenities, such as low-cost laundry, gym facilities, front desk services, and security patrol. Some residences have a $5–$6 monthly tax to cover dorm social activities.

Rents range from $734 to $1,638 per month, per student. Details about each of the residences can be found at [http://housing.mit.edu/graduatefamily/residences/](http://housing.mit.edu/graduatefamily/residences/).

MIT graduate housing is assigned through an allocation process administered by the Graduate Housing Office. Students can enter the allocation for fall term housing between March and early May. Assignments are available in late May. A second allocation takes place in November for spring term housing. Rooms that become available outside the allocation process are made available through a waiting list that runs from July through May. Details of the allocation and waiting list are available at [http://housing.mit.edu/graduatefamily/graduate_family_housing/](http://housing.mit.edu/graduatefamily/graduate_family_housing/).

The Graduate and Family Housing Office, located in W59-200, can be reached at graduatehousing@mit.edu or at 617-253-5148.

### Student Family Housing

Approximately 400 graduate and undergraduate families reside in MIT Family Housing. Family Housing is provided in Eastgate, a high-rise apartment building, and Westgate, which consists of a high-rise building and several garden-style buildings. Both communities have an active student government that plans and facilitates social and cultural events for the entire family. Apartments range from efficiencies to 2-bedroom apartments and are all unfurnished.

Residence in student family housing is limited to regular undergraduate and graduate students who are registered and attending MIT and whose families reside together on a full-time basis, and to single parents with at least one child in residence. Except during the summer, students must be registered each term in order to reside in on-campus student housing. New graduate student assignments are either for one and a half or two years depending on the start date of the student’s program, with a new license agreement signed each year. Married undergraduates or undergraduates with children may live in Family Housing during their eight semesters of guaranteed housing. Returning students who receive housing through the Continuing Allocation Process may remain in housing continuously until they graduate, as long as they are registered each term. They will also sign a new license agreement each year.

Eastgate and Westgate each have an MIT staff person in residence to provide active support to the community. Each building has a playground and Cambridge school buses stop at the buildings.

The rent for all family residences is charged on a monthly basis and the licenses are from the date of occupancy until August 15 each year. Family Housing’s strict termination policies can be found on its website. All rents include heat, hot water, electricity, internet, and basic cable. Building amenities include low-cost laundry, playrooms, barbecues, and other common spaces.

Rents range from $1,192 to $1,764 per month, per apartment. Details about each of the residences can be found at [http://housing.mit.edu/graduatefamily/residences/](http://housing.mit.edu/graduatefamily/residences/).

Student family housing is managed by the MIT Graduate and Family Housing Office and is assigned through an allocation process. Students can enter the allocation for fall term housing between March and early May. Assignments are available in late May. A second allocation takes place in November for spring term housing. Apartments that become available outside the allocation process are made available through a waiting list that runs from July through May. Details of the allocation and waiting list are available at [http://housing.mit.edu/graduatefamily/graduate_family_housing/](http://housing.mit.edu/graduatefamily/graduate_family_housing/).

The Graduate and Family Housing Office, located in W59-200, can be reached at graduatehousing@mit.edu or at 617-253-5148.

### Off-Campus Housing

Students who do not live on campus can consult the Off-Campus Housing Service, which maintains listings of available rentals in the greater Boston area. The staff helps students to locate accommodations that suit individual preferences and finances, and advises and assists them during their tenancy if difficulties arise. Address correspondence to Off-Campus Housing Service, Room W59-200, 617-253-1493, or visit [http://housing.mit.edu/off_campus/off_campus_housing/](http://housing.mit.edu/off_campus/off_campus_housing/).

### INFORMATION SERVICES AND TECHNOLOGY

MIT’s computing environment supports a rich array of technologies and information resources for academic, research, and administrative use. The Information Services and Technology (IS&T) department supports “universal” services and facilities for everyone, including MITnet (the campus network), the Athena Computing Environment (centrally provided hardware and software resources), the on-campus telephone system, co-location services for high-performance research computers, and a variety of support services.

MITnet connects thousands of computers across the campus and its connection to the internet gives MIT high-speed access to computers around the world. The MIT campus is fully wireless and provides an extensive Mobile Web application.

The Athena Computing Environment is MIT’s academic computing environment, which powers computing clusters (labs), private workstations, remote-access servers, and personal machines throughout campus. Athena provides a vast collection of third-party software, including popular packages such as MATLAB, Maple, and Mathematica, and provides easy access to the AFS file system for personal and group file storage.

Students increasingly use laptops as part of their coursework on MIT’s campus-wide wireless and wired networks. While MIT does not require that every student own a computer, the vast majority do. IS&T provides recommendations and buying advice for laptops that meet faculty guidelines and are competitively priced.

IS&T provides full support for recommended systems and software through a range of technical help services. The starting point for help is the IS&T Service Desk. The Help Desk also offers on-campus certified warranty repair, installation, and upgrades for the following manufacturers: Apple, Dell, and Lenovo Thinkpads. The Adaptive Technology for Information and Computing program provides technologies for students and staff with disabilities.

For more information on IS&T and computing at MIT, visit [http://ist.mit.edu/](http://ist.mit.edu/). For details on getting started with IT as a student, visit [http://ist.mit.edu/](http://ist.mit.edu/).
Visits to MIT Medical are by appointment, except for urgent care, which is available seven days a week from 7 am to 11 pm. The Mental Health and Counseling Service also has walk-in urgent care hours from 2 pm to 4 pm daily, Monday through Friday. MIT community members should call 617-253-4481 or 617-258-0656 (TTY) day or night for medical advice; for regular appointments, call 617-253-4481. MIT Medical is located in Building E23.

For more information about MIT Medical, including appointment hours, phone numbers, and clinician profiles, visit http://medweb.mit.edu/.

MIT Student Health Plan

The MIT Student Health Plan consists of two plans, the MIT Student Medical Plan and the MIT Student Extended Insurance Plan. Further information on both can be found under Medical Requirements in the sections on Undergraduate Education and Graduate Education.

ONLINE LEARNING RESOURCES

MITx and edX

MITx is the Institute’s interactive learning initiative that offers online versions of MIT courses to learners around the world. It features video lesson segments, embedded quizzes, immediate feedback, online laboratories, and student-to-student communications. MITx operates on a free of cost, open-source, scalable software infrastructure in order to promote its continuous improvement as well as its adoption and adaptation by individuals as well as other educational institutions. Course materials are organized and presented in ways that enable students to learn at their own pace and that allow for the individual assessment of any student’s work. Students who demonstrate their mastery of subjects may earn a certificate of completion.

MITx is a part of edX, a partnership in online education between MIT and Harvard University. The Institute expects that the edX instructional platform will build a global community of online learners as well as enhance the learning experience of its resident students by offering online tools and methods that supplement and enrich the on-campus classroom and laboratory experience. MIT and Harvard will use the jointly operated edX platform to research how students learn and how technologies can facilitate effective teaching both on campus and online.

For more information, visit http://www.mitx.mit.edu/ and http://www.edxonline.org/.

MIT OpenCourseWare

MIT OpenCourseWare (OCW), available at http://ocw.mit.edu/, is a large-scale, web-based publication of the educational materials from virtually all of the MIT faculty’s courses. This unique initiative enables the open sharing of MIT teaching materials with educators, enrolled students, and self-learners around the world.

OCW provides open access to the core academic content—syllabi, lecture notes, course calendars, problem sets and solutions, exams, reading lists, and even a selection of video lectures—from MIT courses representing 33 academic disciplines and all five of MIT’s schools. As of March 2012, the initiative includes materials from more than 2,103 courses, presenting virtually the entire curriculum of the Institute.
At MIT, OCW’s impact has been felt across the campus. Students use resources such as problem sets and exams for study and practice. Some instructors refer students to OCW for part of their coursework, and a number of faculty members use OCW materials in their classroom teaching. Alumni access OCW materials to continue their lifelong learning.

Course materials contained on the OCW website may be freely used, copied, distributed, translated, and modified by anyone, anywhere in the world for noncommercial purposes. Truly a global initiative, OCW materials have been visited by more than 99 million individuals to date. Visitors have come to the site from more than 215 countries, territories, and city-states around the globe—including every member of the United Nations—and materials already have been translated into at least 10 different languages.

MIT has also been instrumental in establishing the OCW Consortium, which brings together practitioners from more than 250 institutions around the world.

For more information about MIT OpenCourseWare, contact Steve Carson, Room E70-810, 1 Broadway, 8th floor, MIT, 617-253-1250, ocw-outreach@mit.edu.

PUBLIC SERVICE CENTER

The Public Service Center (PSC) offers MIT students multiple ways to assist communities beyond MIT while expanding their own education and life experiences. The guidance, resources, and support offered by the PSC help students to identify public service options that suit their passions and abilities.

The PSC helps students gain hands-on experiences that serve communities and the students themselves in life-transforming ways. Through fellowships, internships, and grants, the IDEAS Global Challenge, programs such as Four Weeks for America and the Freshmen Urban Program (FUP), community service work-study positions, and advising resources, students have the opportunity to engage in a variety of opportunities.

Fellowships, Value-Added Internships, and Grants. In locations as near as Boston or as far as India, there are many opportunities to work on community issues, whether it is designing community spaces for domestic violence survivors in Boston, scrutinizing labor practices in the electronics industry in Mexico, or testing an electronic pill box in India. Students can work individually or as part of a team on projects during IAP, summer, and the academic year.

The MIT IDEAS Global Challenge. Students form teams to work with a community partner to design and implement innovative projects that improve the quality of life in communities around the world. Since 2001, the IDEAS Global Challenge has awarded over $400,000 to more than 75 teams to make their ideas a reality. As a result of implementation funds awarded to teams, communities around the world have directly benefited from these innovations.

Programs, Planning, and Volunteering. Through local outreach programs, MIT students can work with a K–12 science classroom, serve as a mentor to adolescents in math and science, or teach a child to read. FUP, Giving Tree, and ReachOut are among the programs led by students under the direction of the PSC. In the Four Weeks for America program, students work with Teach for America teachers during the Independent Activities Period to help them develop innovative ways to teach science and math and increase classroom learning. Student Leaders in Service, part of AmeriCorps, allows students to volunteer in the community in exchange for an education award. Also, PSC staff advise students about international and local volunteer opportunities, service group management, grants and proposal writing, and other areas that help MIT students and groups to participate in community service.

Community Service Work-Study. Students who qualify for Federal Work-Study are able to add to their work experience while assisting nonprofit organizations with the problems they face.

The innovative and engaging outreach activities available through the student groups, residence-based activities, departments, and programs at MIT are too numerous to name. A sampling of groups can be found online through the MIT Outreach Database, http://web.mit.edu/outreach/. The PSC website, http://web.mit.edu/mitpsc/, is a useful resource for finding out more about the varied and exciting ways to participate in public service at MIT. For further information, contact the PSC at 617-253-0742 or psc@mit.edu.

RELIGIOUS ORGANIZATIONS

There are currently about 30 active and long-standing student religious organizations on campus that are based in the Chapel and Building W11. Ministers representing the major faiths devote all or a large part of their time to on-campus activities, counseling individual students, and advising student religious organizations.

The first chaplain to the Institute was appointed in 2007. This decision reflects the recognition that religious convictions appear increasingly important as personal identity markers. MIT considers that one of its responsibilities is to maintain an atmosphere of religious freedom for all and to provide all members of the MIT community opportunity for the exercise of spiritual interests. The chaplain to the Institute monitors that responsibility and offers support and counsel in times of loss and trauma.

STUDENT DISABILITIES SERVICES

Student Disabilities Services (SDS) is responsible for coordinating the Institute’s efforts to comply with the Americans with Disabilities Act of 1990 and Section 504 of the Rehabilitation Act of 1973. SDS provides qualified students with disabilities equal access to all Institute programs, activities, and services. The goals of SDS’s support services are to encourage students to be self-sufficient, to enhance the educational process, and to support overall personal and professional development of students without compromising existing academic standards.

These services include receiving and reviewing disability-related documentation and determining the appropriate accommodations required, communicating with faculty (with the student’s permission), and develop-
ing plans for accommodations. Student Disabilities Services also provides, or arranges, a variety of auxiliary services for qualified students with disabilities, such as coordination of sign language interpreters, text alternatives, and other academic accommodations. Student Disabilities Services is located in Room 7-145. For further information, call 617-253-1674 or visit http://web.mit.edu/uaap/sds/.

STUDENT GOVERNMENT

Undergraduate Student Government
The Undergraduate Association (UA), the major governmental body to which all undergraduates belong, works to improve the quality of undergraduate life. It is assisted by a variety of committees. The Finance Board coordinates budgets and allocates funds to student organizations. The Committee on Educational Policy proposes educational reforms and provides student feedback to the departments and the Institute on important educational issues. The Nominations Committee recommends student representatives for more than 50 administrative and faculty committees. Each class at MIT annually elects a president and executive committee for its class council, which plans and coordinates programs and social events throughout the year.

The Association of Student Activities, a joint committee of the UA and the Student Body Council (see below), is responsible for recognizing student groups and activities, allocating student office space, and organizing the Activities Midway, which takes place during orientation in August. All living groups determine governing structures responsible for the functioning of their houses, including sponsoring social events and handling judicial matters within the respective houses. To deal with problems of common concern, the fraternities have formed the Interfraternity Council (IFC), the sororities have formed the Panhellenic Council, and the Institute houses have formed the Dormitory Council. The IFC and Panhellenic Council work to improve relations between fraternities and sororities and Boston’s Back Bay community. The Dormitory Council coordinates common house activities, such as freshman orientation, and major social events, and handles interhouse judicial problems.

Graduate Student Government
The Graduate Student Council (GSC) exists to enhance the overall graduate experience at MIT by promoting the general welfare and concerns of the graduate student body, creating new programs and initiatives, and communicating with the MIT faculty and administration on behalf of graduate students. The GSC seeks to emphasize, in all its activities, the core values of representation, communication, collaboration, transparency, and accountability.

The council accomplishes its goals through a structure of elected representatives, standing committees, and officers. GSC representatives facilitate communication between the council and their constituency (a department, academic program, living group, or demographic group). The standing committees span all facets of the graduate experience, including orientation for all incoming graduate students, the career fair and a variety of academic seminars throughout the year, large social and cultural activities, and even the Muddy Charles Pub.

On issues such as housing, stipends, health care, and advising, as well as nearly any other academic or student-life related issue, the GSC serves as the primary voice and advocate for the graduate student body. In addition, the GSC nominates individuals to serve on a number of Institute committees, to ensure that there is a student voice in decisions made throughout the Institute.

The GSC also interfaces with graduate student groups through the Association of Student Activities (a joint committee of the GSC and the Undergraduate Association) and the GSC funding board, which allocates event funding to these groups. Additionally, the GSC maintains relations with other graduate student organizations both locally and nationally so as to share ideas about how to best address graduate students' needs.

The GSC office is located in Room 50-220, Walker Memorial, above the Muddy Charles Pub. To keep students apprised of the council’s activities, it maintains a comprehensive website at http://gsc.mit.edu/ which serves as a repository for a large amount of information relevant to graduate students; it also periodically publishes The Graduate.

STUDENT SERVICES CENTER

The Student Services Center, conveniently located along the Infinite Corridor in Room 11-120, provides students and their parents with information about their student bills, financial aid, loans, payment plans, registration, transcripts, and a variety of other academic and financial matters. Students can also pick up or drop off many Institute forms. Copies of MIT’s course catalog can be obtained at the center as well.

The Student Services Center is open Monday, Tuesday, Thursday, and Friday from 9 am to 5 pm, and Wednesday from 10 am to 5 pm. For further information, call 617-258-8600 or email sfs@mit.edu. Visit http://web.mit.edu/sfs/about_us/ for a complete description of the financial services available to students.

WEBSIS

WebSIS is the web-based student information system for students, faculty, and staff. Through WebSIS students can preregister and register for classes, check grades, maintain personal information, apply for their degrees, track financial aid requirements, complete loan entrance counseling, and view current student account activity; advisors and administrators can view the academic records of students in their departments, approve degree applicants, and access online registration; instructors and administrators can access enrollment lists, student photographs, prerequisite reports, online subject evaluations, and online grading for their classes.

For more information visit http://student.mit.edu/.
To earn a bachelor’s degree, undergraduates must complete the General Institute Requirements as well as the course of study prescribed for the degree to be awarded. This section outlines the general requirements together with other important aspects of undergraduate education, including admissions and financial aid.
ACADEMIC PROGRAMS

The undergraduate programs at MIT are designed to help students develop the knowledge and capabilities needed to meet the challenges of modern society. An MIT education joins the power of a specific discipline to a concern for social values and goals. In addition to developing expertise in a given field, undergraduates are encouraged to take advantage of the opportunities for broad learning at MIT, and to become creative, intellectual leaders and problem solvers, whose passion for learning is lifelong.

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

MIT students base their studies on a core of subjects in science, mathematics, and the humanities, arts, and social sciences (the General Institute Requirements). They major in the physical or biological sciences, in management science, in architecture or urban studies and planning, in an area of the humanities, arts, and social sciences, or in one of the engineering fields. In the first year, many students take subjects from a variety of options in mathematics, physics, chemistry, biology, and humanities, arts, and social sciences. During the second year, students generally continue their studies with subjects meeting various Institute requirements and beginning subjects in departmental programs. In the third and fourth years, students focus on the departmental programs.

There is also time for students to take elective subjects each year. These elective opportunities allow students to follow social interests or to enrich their educational backgrounds. Students may also use elective time to prepare for study in a professional field such as medicine or law or to begin work toward graduate study. Students may also pursue minors in many fields.

One of the most exciting features of undergraduate education at MIT is the opportunity for students to join with faculty in ongoing research projects. For example, experiences in the Undergraduate Research Opportunities Program (UROP) encourage intellectual commitment and self-direction, and often provide a focus for students’ undergraduate studies. During the Independent Activities Period in January, students can spend time in workshops, independent research projects, intensive subjects and seminars, field trips, lecture series, and other activities that do not easily fit into the traditional academic calendar.

To complete work for a bachelor’s degree in any Course (major), each student must fulfill the General Institute Requirements and must complete the departmental program specified by that Course. Details on General Institute Requirements and on selecting a major course of study are discussed later in this section.

The program for the SB takes four years of full-time study for most students. Of the freshmen who entered between 2001 and 2005, the percentage of students who received their degrees within six years of entrance was about 93 percent.

Freshman Year

During the first year at MIT, students lay the foundation for their college education. First-year students may accommodate their individual preparation and learning styles by choosing among a variety of ways to complete the core subjects and prepare for further undergraduate study.

To begin fulfilling the General Institute Requirements (described later in this section), freshmen choose subjects in mathematics, chemistry, biology, and physics to fulfill the science core, and select from a wide range of subjects in the humanities, arts, and social sciences (HASS subjects). Students have various options for satisfying the first year of the Communication Requirement.

A normal program for the first year includes completion of four or five of the six science core subjects in mathematics, physics, biology, and chemistry, and two of the eight HASS subjects, including a Communication-Intensive subject. Students may round out their programs with electives, often including Freshman Advising Seminars (led by the students’ advisors). Some freshmen also elect to become involved in the Undergraduate Research Opportunities Program, described later in this section.

Entering students with degree credit for one or more of the science core requirements may substitute more advanced subjects or may take electives or Restricted Electives in Science and Technology (REST) Requirement subjects. Procedures for obtaining degree credit at entrance are described in the Admissions section.

Students may also enroll in one of the special freshman learning communities: the Concourse Program, the Experimental Study Group, the Media Arts and Sciences Freshman Program, and Terrascope. These learning communities have their own faculty, meeting places, 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 from program to program and among students within each program. In all four programs there is an especially high level of student-faculty interaction.

Concourse Program

Concourse is a small community of students and faculty dedicated to exploring the fundamental questions at the heart of all serious human inquiry. The program offers small classes with rigorous instruction in the science and math General Institute Requirements, as well as in the humanities. In the humanities curriculum and Freshman Advising Seminar, we raise questions and encourage debate about human nature, ethics, the proper role of science in society, and the possibility and character of true happiness. Concourse provides the advantages of a small school while retaining the vast range of opportunities offered by the Institute as a whole. Concourse students have close interactions with instructors and fellow students as well as Concourse Program alumni and prominent guest speakers in diverse fields from MIT and elsewhere. The intimacy of the community allows teaching faculty from a number of different disciplines to gather in one place, enabling formal and informal cross-disciplinary exploration. The approach is that of a scholarly community with intense participation and support by faculty, staff, student assistants, and freshmen. The curriculum is demanding and challenging.
The program’s facilities lie at the heart of the MIT campus and consist of a dedicated classroom and lounge, complete with kitchen and seminar room. Students and faculty meet frequently in the 24/7 lounge, not only for study but also for discussions, class tutorials, weekly Friday lunches, and even the occasional breakfast and dinner. All Concourse students are required to sign up for the Freshman Advising Seminar by June 17 and to take at least two additional subjects within Concourse, including one humanities subject. Please see the Councourse website for more details and instructions for applying.

For more information, contact Paula Cogliano, Room 16-135, 617-253-0334, vmb@mit.edu, or visit http://concourse.mit.edu/.

Experimental Study Group
The Experimental Study Group (ESG) is a close-knit academic program geared primarily toward motivated first-year students who wish to take an active part in their MIT education. Each year 50 freshmen, eight staff members, and 25 upperclass instructors (most of whom were in ESG as freshmen) participate in the program. Staff members are selected for their teaching ability and strong interest in community-based education and are drawn from the departments of Biology, Chemistry, Mathematics, Physics, and the School of Humanities, Arts, and Social Sciences.

In place of lectures and large classes, ESG students participate in small interactive classes (typically fewer than 12 students), discussion-based seminars, study groups, and tutorials. Almost all the core subjects in biology, chemistry, mathematics, and physics are offered through ESG, as well as a CI-HW writing class. Although ESG can be a full-time activity for freshmen, students may take one or two subjects outside of ESG, including a Freshman Advising Seminar.

ESG’s small classes are structured to be active learning environments with plenty of opportunity for lively discussion, question-and-answer sessions, student presentations, and peer-led problem-solving sessions. ESG also promotes educational innovation by encouraging staff and students to design and teach experimental 6-unit seminars that combine theory and practice. Seminars offered this past year include diverse topics such as The Chemistry of Sports, More Than A Website, The Art and Science of Happiness, Introduction to Trading, and Speaking Italian... With Your Mouth Full!

ESG’s centrally located facility is comprised of 14 rooms (including a central lounge and a kitchen) where classes are held and weekly activities are offered, such as luncheons and dinners, guest speakers, and evening study sessions. Students and staff also plan regular outings for the central lounge and a kitchen) where classes are held and weekly activities are offered, such as luncheons and dinners, guest speakers, and evening study sessions. Students and staff also plan regular outings for the

For more information about ESG, contact Dr. Holly Sweet, associate director, Room 24-612, 617-253-7786, hbsweet@mit.edu, or visit http://web.mit.edu/esg/.

Media Arts and Sciences Freshman Program
The Program in Media Arts and Sciences (MAS) offers a special freshman program emphasizing research at MIT’s internationally known Media Laboratory. In the freshman program, instructors connect research topics in the Media Laboratory to core physics and chemistry subjects, and students learn firsthand how research is carried out.

The Program in Media Arts and Sciences is part of the School of Architecture and Planning. It is housed in the Media Laboratory, which carries on advanced research in the invention and creative use of technology to enhance communication and expression. (For more information on Media Arts and Sciences, see Part 2; for more information on the Media Laboratory, see Interdisciplinary Research and Study in Part 3.)

Up to 24 freshmen in the MAS Freshman Program are introduced to the learning-by-apprenticeship mode that characterizes MAS. During the fall term, students may choose to take part in one of several MAS Freshman Advising Seminars, and take MAS.110 Fundamentals of Computational Media Design, with hands-on design exercises looking at the intersection between expression and technology. In the spring term they take MAS.111 Introduction to Doing Research in Media Arts and Sciences, which includes documenting and presenting research results. In conjunction with MAS.111, all students participate through the Undergraduate Research Opportunities Program (UROP) in one of the research projects at the Media Laboratory. (For descriptions of the MAS subjects, see the online MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi; a description of UROP can be found later in this section.)

Researchers from the Media Laboratory teach recitation or tutorial sections in the fall for subjects 8.01 and 3.091 and in the spring for 8.02, in which they emphasize connections between the fundamentals of physics and chemistry and ongoing research at the Media Laboratory. Students take the lectures for these subjects, as well as lectures and recitations in other core and elective subjects, with other freshmen. (For descriptions of these subjects, see the online MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.)

For information, please contact program director Dr. V. Michael Bove, Jr., 617-253-0334, vmb@mit.edu, or visit http://www.media.mit.edu/mas/fyo/.

Terrascope
Terrascope is a learning community with curricula designed to give students the tools to address important, complex problems that require integrative, multidisciplinary solutions. Students work as part of an interdisciplinary team to solve problems related to the Earth’s environment and sustainability and that offer a unique way to explore the feedbacks that characterize the behavior of complex dynamical systems.

During the fall term, Terrascope students enroll in 12.000 Solving Complex Problems (9 units), a popular subject (also known as Mission 2016 for fall 2012) that explores how teams of scientists and engineers approach difficult problems that require multidisciplinary approaches. Solutions are published on a class website and participants defend their work before a panel of outside experts. This final presentation is broadcast live over the internet.

In the spring, 1.016 Design for Complex Environmental Issues (9 units) allows students and a team to develop and expand some of the solutions proposed in the fall. SP360 Terrascope Radio (12 units) fulfills a Communication Requirement (CI-H credit) as students produce a professional-quality radio program on the year’s subject.

Students fulfill General Institute Requirements by attending mainstream core subjects with other first-year students.
Terrascope students are advised by faculty and staff affiliated with the program. Fieldwork and close interactions with researchers and others are an important part of the Terrascope experience. Terrascope students attend weekly lunch seminars during which researchers and others speak about their work. Students in the program can choose to participate in a weeklong field trip over spring break to a site related to the year’s work. Past locations have included Abu Dhabi, Alaska, the Amazon rainforest, Arizona, Chile, the Galapagos Islands, Iceland, and New Orleans.

Terrascope offers students a variety of exclusive facilities, including classroom and study space, a kitchen, and a lounge.

For more information, or to apply for the program, visit http://web.mit.edu/terrascpe/.

Seminar XL
Seminar XL is a collaborative undergraduate learning experience in which groups of four to six students meet for 90 minutes twice per week to share their understanding of course concepts and problem-solving methods. Each group is guided by a facilitator who is a research scientist, a graduate student, or an upperclass undergraduate student who previously earned an A in the course. Although the Office of Minority Education (OME) historically has sponsored the program for first-year students, OME encourages upperclass students to enroll as well. However, only first-year students may receive course credit, provided they attend at least 80 percent of the working group sessions. Upperclass students must register as listeners.

After the fifth week, interested students may enroll in Seminar XL Limited Edition, which operates two 90-minute working group sessions per week, as does the regular Seminar XL. There is no course credit awarded, but past students have benefited greatly from this program.

For more information about Seminar XL, Seminar XL LE, and other OME services, visit the Office of Minority Education, Room 4-107, 617-253-5010, or visit http://ome.mit.edu/programs-services/seminar-xl/.

First-year Academics
The preceding overview conveys the nature and scope of the academic options for first-year students. Incoming freshmen are referred to http://web.mit.edu/firstyear/ for detailed information on academics, the advisory system, and support services.

Freshman Grading
In the first term and IAP, freshmen are graded on a pass or no-record basis. They receive grades of P, D, or F in all subjects they take, where P indicates C or better performance (C- with modifier used within MIT). Freshmen receive no credit for subjects with D or F grades and these subjects do not appear on their transcripts.

In the second term, freshmen are graded on an A, B, C, or no-record basis. They continue to receive no credit for subjects with D or F grades, which do not appear on their transcripts. The A, B, or C grades are used in calculating students’ term and cumulative ratings.

Freshman grading is designed to ease the transition from high school by giving students time to adjust to factors like increased workloads and variations in academic preparation. Students are encouraged to improve time-management skills and develop more mature attitudes about learning. A, B, and C grades are used during the second term so that freshmen can begin the progression to regular A-F grading in the sophomore year.

Use of Hidden Grades
MIT’s educational policy is to provide “hidden” grades to students for educational and advising purposes only. MIT will not release hidden grades to any outside organization or individual, and these grades are never included on an external transcript. For more information, see the First Year website.

Credit Limit for Freshmen
A freshman may not register or receive credit for subjects totaling more than 54 units in the fall term and 57 units in the spring term. The Committee on Academic Performance (CAP) rarely grants requests to exceed the credit limit. (Only in the fall term may freshmen exceed the 54-unit credit limit by 3 units to take 12.000 Solving Complex Problems or by 6 units to take Seminar XL.) Credit earned for passing an Advanced Standing Examination will be counted toward the term credit limit unless the exam is taken either in the September or February examination period. ROTC subjects (listed in the online MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi) are excluded from this credit limit.

Note that all MIT students are limited to 12 units during the Independent Activities Period in January.

Major Course of Study
Whether or not they enter with plans for a specific field of study, all students are encouraged to examine with an open mind the wide range of Courses (majors) available at the Institute. Students may attend departmental orientation programs to talk with faculty and others with experience in fields of potential interest. They should select electives that will help them think about possible majors. The Independent Activities Period in January, described later in this section, provides students with opportunities to investigate different fields. For many students, this consideration of fields will reinforce existing convictions, while for others it will open up new avenues of interest. MIT may, however, limit enrollment in particular fields of study to balance resources with student interest.

Each student entering MIT is assigned an advisor who assists the student in designing an effective program of study. The selection of elective subjects is an important consideration, one that students should discuss in depth with their advisors.

All undergraduate degree programs combine the study of basic principles with practical applications. This combination helps to motivate the lifelong learning necessary for professional competence.

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

All undergraduate and graduate academic programs, as well as faculty listings for each of the Institute’s departments, are described fully in Parts 2 and 3.

Detailed information on undergraduate registration may be found in Academic Procedures and Institute Regulations in Part 1.
**Electives**

Electives may be used for several different purposes. For example, students who are undecided about their eventual majors may decide to use some portion of their electives to explore the various departments or fields they are considering. Students more certain of their academic and professional goals may choose to use electives to explore areas of secondary interest. Still other students focus first on departmental or General Institute Requirements, deferring subjects of a more supplemental nature until a later year. The study of a language may also be started or continued.

Freshmen should select electives that best suit their individual needs. There are several hundred subjects without prerequisites that are especially appropriate for first-year students. However, in general, any subject offered by the Institute is open to all students, provided they satisfy the prerequisites.

**Double Majors**

Students may earn a bachelor’s degree with two majors by successfully completing the GIRs and the departmental requirements for each major. To add a second major, a student must apply to the Committee on Curricula (COC) by Add Date of his or her penultimate term. Applications submitted after this deadline will be considered by the COC at its discretion on a case-by-case basis.

A double major program should be completed in a four- or five-year period and should be planned in advance. A student’s plan for completing both majors must be outlined in the application to the COC. The application must also include the expected completion date for the degree, and it must be approved by both programs. Students should consult Student Financial Services regarding any impact that pursuing a double major might have on their eligibility for MIT or federal financial aid, particularly if they anticipate needing more than eight semesters to complete their studies.

Students must select a second major in a different area from the primary major. Students pursuing a double major may also complete up to two minors, but a minor may not be taken in the same area as either of the major programs.

Only registered undergraduates who have completed at least three terms at MIT, including at least one term with a declared major, may apply. Transfer students must complete at least two terms at MIT, including at least one term with a declared major. Students with cumulative averages below 4.0 will not be considered except in exceptional cases. A student who has previously earned a bachelor’s degree with a single major may not return to complete a second major.

For details on eligibility, deadlines, and procedures, see the COC website, [http://web.mit.edu/doublemajor/](http://web.mit.edu/doublemajor/).

**Minors**

The objective of a minor is to provide a depth of understanding and expertise to an area outside of, or complementary to, a student’s major. This depth and expertise must be sufficient to enable the student to appreciate the complexities and issues that are central to the minor, and to perform at a level sufficient to solve realistic problems and/or to make a contribution to the field. A number of programs in science, engineering, architecture, management, and the humanities, arts, and social sciences offer minors.

Several interdisciplinary minors, including an Institute-wide minor in energy studies, are also available; for further information on interdisciplinary minors, see the Interdisciplinary Undergraduate Programs and Minors section in Part 3.

Students who successfully complete minors will have their fields of study specified on their transcripts as part of their Bachelor of Science degrees, thus giving public recognition of this focused work. Minors may be pursued within the following framework:

- A student may not minor in the area of his or her major. For example, a student majoring in biological engineering may not pursue a minor in biomedical engineering. In addition, if a student is pursuing a composite (joint) degree (such as the SB in Mathematics with Computer Science or the SB in Computer Science and Molecular Biology), he or she may not pursue a minor in either field of that program. The Committee on Curricula (COC) has the authority to determine whether a specific combination is permissible.
- At the discretion of a student’s major department, subjects taken for a minor may count toward departmental program requirements, provided the student’s combination of programs is permitted by the COC.

The general guidelines for a minor program are as follows:

- Minors consist of five to seven subjects, with a typical program comprising six. A minor may include subjects that count toward General Institute Requirements (GIRs).
- Subjects taken under the junior-senior P/D/F grading option cannot be used for a minor program.
- At the discretion of the minor advisor, approved transfer credit may be used to fulfill a portion of the minor program. MIT subjects, including those taken through cross-registration, must comprise at least half of the minor program.
- A student may earn no more than two minors, which are awarded only when the student receives the SB degree, and which must be associated with a specific degree. This two-minor maximum applies even if the student receives a double major.
- The student should apply for a minor by the end of the sophomore year, but no later than Add Date one full term preceding the one in which the SB degree is awarded. The student must complete an application form for a minor in consultation with the appropriate minor advisor. Note that application and completion forms vary among programs.

Minors are currently available in the fields listed below. Programs marked with an asterisk are HASS minors, which may be built on the concentration component of the HASS General Institute Requirement. Of the six subjects required for a HASS minor, at most five may count toward the eight-subject HASS Requirement. Of these five, at most one may count toward satisfying the distribution component of the HASS Requirement. Programs marked with a dagger are described in the Interdisciplinary Undergraduate Programs and Minors section in Part 3.

More information on departmental minors appears in Part 2.
African and African Diaspora Studies*†
Ancient and Medieval Studies*†
Anthropology*
Applied International Studies*†
Architecture
Art, Culture, and Technology*
Asian and Asian Diaspora Studies*†
Astronomy†
Biology
Biomedical Engineering†
Brain and Cognitive Sciences
Chemistry
Civil Engineering
Comparative Media Studies*
Earth, Atmospheric, and Planetary Sciences
Economics*
Energy Studies†
Environmental Engineering Science
French*
German*
History*
History of Architecture and Art*
International Development*
Japanese*
Latin American and Latino Studies*†
Linguistics*
Literature*
Management
Management Science
Materials Science and Engineering
Mathematics
Mechanical Engineering
Middle Eastern Studies*†
Music*
Nuclear Science and Engineering
Philosophy*
Physics
Political Science*
Psychology*†
Public Policy*†
Russian and Eurasian Studies*†
Science, Technology, and Society*
Spanish*
Theater Arts*
Toxicology and Environmental Health
Urban Studies and Planning*
Women’s and Gender Studies*†
Writing*

For additional information, instructions, and applications, students should contact the undergraduate office in their field of interest, or the Office of Undergraduate Advising and Academic Programming in Room 7-104. Information about HASS minors is available in the Office of the Dean, School of Humanities, Arts, and Social Sciences (Room 4-240) or at http://shass.mit.edu/undergraduate/mmj/minors/.

GENERAL INSTITUTE REQUIREMENTS

To be recommended for the degree of Bachelor of Science, students must have attended the Institute not less than three regular academic terms, which ordinarily must include the term of graduation. Also, students must have satisfactorily completed programs of study approved in accordance with the faculty regulations, including the General Institute Requirements (GIRs) described on the following pages, and the departmental program of the Course in which the degree is to be awarded. A student must petition the Subcommittee on the Communication Requirement (SOCR) for any substitutions in the Communication Requirement; the Subcommittee on the HASS Requirement (SHR) for any substitutions in the Humanities, Arts, and Social Sciences (HASS) Requirement; and the Committee on Curricula (COC) for any substitutions in other GIRs. Departures from the departmental programs are allowed with departmental permission. The departmental programs and degree requirements appear in Part 2.

Science Requirement

MIT expects its graduates to have an understanding and appreciation of the basic concepts and methods of the physical and biological 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 MIT graduates bring to their roles as professionals and as broadly educated citizens in a world strongly influenced by science and technology.

Students begin with six science core subjects in mathematics, physics, biology, and chemistry, and then add the Laboratory and Restricted Electives in Science and Technology (REST) Requirements, both described later in this section. These programs introduce 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 and biology requirements and by the Laboratory Requirement. Mathematical methods common to much of science and technology are explored in the mathematics requirement. Basic concepts that underlie many physical phenomena are defined and elucidated in the physics and REST requirements.

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

The development of critical and constructive approaches to both theory and practice in science, engineering, and other professions is a central objective of the Institute’s educational programs.
Biology
The Institute requirement in biology may be satisfied by one of three introductory subjects, 7.012, 7.013, or 7.014. These three subjects, denoted as Biology (GIR), cover the same core material, which includes the fundamental principles of biochemistry, genetics, molecular biology, and cell biology. In addition, each subject has its own distinctive material. Subject 7.012 is offered in the fall term; 7.013 and 7.014 are taught in the spring.

Chemistry
The Institute requirement in chemistry may be satisfied by taking 3.091 Introduction to Solid-State Chemistry, or 5.111 or 5.112 Principles of Chemical Science. These three subjects are denoted as Chemistry (GIR). Subject 3.091 is designed for students who are particularly interested in the chemistry of the solid state. Subjects 5.111 and 5.112 emphasize basic chemical principles and their applications. Subject 5.112 is intended for students with a strong background in high school chemistry. The content of subjects 5.111 and 5.112 is formally coordinated with more advanced subjects taught by the Department of Chemistry (e.g., 5.60 and 5.12), although any one of the three GIR subjects (5.111, 5.112, or 3.091) may be used as the prerequisite for those more advanced subjects.

Mathematics
The Institute requires all students to complete single variable calculus [18.01 or equivalent, denoted as Calculus I (GIR)] and multivariable calculus [18.02 or equivalent, denoted as Calculus II (GIR)].

Students with advanced-standing, advanced-placement, or transfer credit for 18.01 may go directly into multivariable calculus. Two versions are offered in the fall term: 18.02, the basic version, and 18.022, a somewhat more theoretical version. Both 18.02 and 18.022 present calculus as it is used in science and engineering.

The sequence 18.014–18.024 Calculus with Theory assumes a substantial background in calculus and emphasizes proofs.

Students with a year of high school calculus may qualify for 18.01A–18.02A. This sequence covers the material in one and a half terms. (See the online MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi, for more information.)

Students with advanced-placement, advanced-standing, or transfer credit for 18.01 will lose it if they take 18.01, will receive 3 units of elective credit if they take 18.01A, and will receive 9 units of elective credit if they take 18.014.

Physics
The Institute requirement in physics may be satisfied through several combinations of introductory physics subjects. Subjects 8.01, 8.01L, 8.011, and 8.012 are denoted as Physics I (GIR); 8.02, 8.021, and 8.022 are denoted as Physics II (GIR). Most students find the 8.01–8.02 sequence suited to their needs. The sequence 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. Subject 8.011 is offered in the fall term for students who have had little exposure to physics with calculus in high school. A student may switch from a Physics I (GIR) subject in one sequence to a Physics II (GIR) subject in another.

Bachelor of Science Degree Requirements

<table>
<thead>
<tr>
<th>General Institute Requirements (GIRs)</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement:</td>
<td>6</td>
</tr>
<tr>
<td>Chemistry (5.091, 5.111, or 5.112)</td>
<td></td>
</tr>
<tr>
<td>Physics (8.01, 8.011, 8.012, or 8.01; and 8.02, 8.021, or 8.022) Calculus (18.01, 18.01A, or 18.014; and 18.02, 18.02A, 18.022, 18.023, or 18.024) Biology (7.012, 7.013, or 7.014)</td>
<td></td>
</tr>
<tr>
<td>Laboratory (LAB) Requirement (12 units)</td>
<td>1</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>2</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement includes 2 Communication Requirement subjects (CI-H)</td>
<td>8</td>
</tr>
<tr>
<td>Total GIR Subjects Required for SB Degree</td>
<td>17</td>
</tr>
</tbody>
</table>

Communication Requirement, to be satisfied by 4 subjects:
2 Communication-Intensive HASS subjects (CI-H)
2 Communication-Intensive Major subjects (CI-M)

Physical Education Requirement

PLUS Departmental Program and Unrestricted Electives
The departmental program may specify some of the GIR subjects, and includes 180–198 additional units beyond the GIRs.

Students track their progress by checking off the subjects that count towards the 17 GIR subjects. The remaining units then count toward the additional 180–198 units beyond the General Institute Requirements. Students are allowed a minimum of 48 units of unrestricted electives.

Students schedule their programs each year within a normal load of the equivalent 8 or 8 1/2 subjects, and complete all degree requirements within the equivalent of 32–34 subjects.

Notes
Transfer students generally will graduate under the requirements that apply to the class they join when they enter MIT.

Students who score a 5 on Parts I and II of the Physics C Advanced Placement test will receive credit for 8.01.

Students with advanced-placement or advanced-standing credit for 8.01 who elect to take 8.012 will receive 6 units of elective credit in place of 8.01.

Communication Requirement
The Communication Requirement makes the development of effective writing and speaking an integral part of undergraduate education at the Institute. The Communication Requirement ensures that all undergraduates receive substantial instruction and practice in general expository writing and speaking and the forms of discourse common to their professional fields.

The Communication Requirement consists of four Communication-Intensive (CI) subjects sequenced throughout a student’s undergraduate career. Students take two CI subjects in the humanities, arts, and social
sciences (CI-H) and two CI subjects in their major program (CI-M). Students must maintain a minimum pace in completing their CI subjects in order to remain in good standing with the Communication Requirement. They must complete one of their CI subjects by the end of the first year, two by the end of the second, three by the end of the third year, and four by graduation.

Students must earn a passing grade to receive CI credit. CI subjects must be taken for a letter grade. Students may not use their junior-senior P/D/F option. Only one CI-H subject per term may be counted toward completion of the Communication Requirement. However, students may receive credit for more than one CI-M subject in the same term or a CI-H and a CI-M completed concurrently.

The general structure of the requirement is described below. Additional information can be found at [http://web.mit.edu/commreq/]. More information on CI-H subjects is included in the section of the Bulletin on the HASS Requirement. Specifics on the CI-M subjects for each major appear in the descriptions of the individual undergraduate degree programs.

**First year.** Students must pass one CI-H or CI-HW subject by the end of their second term at the Institute. A list of CI-H and CI-HW subjects may be found at [http://web.mit.edu/commreq/cih.html].

Before entering MIT, all students are asked to take the Freshman Essay Evaluation (FEE). The FEE is a placement tool used to determine the best program for each undergraduate within the Communication Requirement. Students who receive a score of “CI-H/CI-HW Required” on the FEE or receive a score of 5 on either the Advanced Placement Language and Composition Test or the Advanced Placement Literature and Composition Test have the option of taking any CI-H subject, including specially designated expository writing subjects (CI-HW).

All other students must take one of the designated CI-HW expository writing subjects as their first CI subject.

Students who do not complete a CI-H/CI-HW subject in their first term at MIT may not advance to sophomore standing in their second term.

**Second year.** Students must pass at least two CI subjects by the end of their fourth term at the Institute. In most cases, these first two CI subjects will satisfy the CI-H portion of the requirement, providing a foundation in written and oral exposition.

**Third year.** Students must pass at least three of the four required CI subjects by the end of their sixth term. Most students will take their first CI-M subject as juniors and begin to develop the communication skills specific to the professional and academic culture of their discipline.

**Before receiving an SB degree.** Students must complete two CI-H subjects and the two CI-M subjects specified for their SB degree program prior to receiving their degree.

**Noncompliance.** Students who fall behind the minimum pace of completion for the Communication Requirement are in noncompliance. At the end of each term, the names of noncompliant students are forwarded to the Committee on Academic Performance, which may take further action to bring such students into good academic standing.

**Double majors.** Students who wish to complete two majors must pass two CI-H subjects and complete the CI-M subjects that fulfill the communication component of each major. Normally, these students will take four CI-M subjects, that is, two in each major program. In certain cases a CI-M subject may be common to both departments and may be used to fulfill the communication component of two majors simultaneously.

**Communication Requirement information.** For more detailed information about CI subjects or for assistance with any aspect of the Communication Requirement, including petitions, visit the Communication Requirement website at [http://web.mit.edu/commreq/]. Students may also contact the Office of the Communication Requirement (commreq@mit.edu) to discuss their individual circumstances.

**Humanities, Arts, and Social Sciences (HASS) Requirement**

MIT provides a substantial and varied program in the humanities, arts, and social sciences that forms an essential part of the education of every undergraduate. This program is intended to ensure that students develop a broad understanding of human society, its traditions, and its institutions. The requirement enables students to deepen their knowledge in a variety of cultural and disciplinary areas and encourages the development of 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 skills in communication, both oral and written; knowledge of human cultures, past and present, and of the ways in which they have influenced one another; awareness of concepts, ideas, and systems of thought that underlie human activities; understanding of the social, political, and economic framework of different societies; and, finally, 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 (HASS) is based on the following Institute requirement:

**Minimum.** Every candidate for a bachelor’s degree must have completed a minimum of eight term subjects in the humanities, arts, and social sciences, including distribution and concentration components. Subjects must be taken for a letter grade and students may not use their junior-senior P/D/F option. Two HASS subjects that are designated Communication Intensive may also be used toward the Communication Requirement. See the description of the Communication Requirement earlier in this section.

**Distribution.** The following description of the distribution component of the HASS Requirement applies to classes that entered in academic year 2010–2011 or thereafter. Students who entered prior to 2010–2011 and transfer students who entered in 2010–2011 should refer to the section below on HASS Distribution subjects for details on their requirement. Additional information is available at [http://web.mit.edu/hassreq/].

Three of the eight subjects must be selected from designated categories: humanities, arts, and social sciences. The three subjects may be taken at any stage of the student’s undergraduate career, although students are encouraged to complete their distribution by the end of their junior year.

**Humanities:** Humanities subjects describe and interpret human achievements, problems, and historical changes at individual as well as societal levels. Although humanist inquiry employs a variety of methods, such disciplines as history, literature, and philosophy typically produce their accounts of cultural accomplishments through close analysis of texts and ideas: contemporary and historical, personal and communal, imaginative and reflective.
Arts: Arts subjects emphasize the skilled craft, practices, and standards of excellence involved in creating representations through images, words, sounds, and movement (e.g., sculptures, stories, plays, music, dance, films, or video games). Although arts subjects also engage in critical interpretation and historical analysis, they focus more centrally on expressive and aesthetic techniques and tools, such as the uses of rhythm, texture, and line.

Social Sciences: Social Science subjects engage in theory-driven as well as empirical exploration and analysis of human transactions. They address the mental and behavioral activities of individuals, groups, organizations, institutions, and nations. Social science disciplines such as anthropology, economics, linguistics, political science, and psychology seek generalizable interpretations and explanations of human interaction.

Concentration. Each student should designate a field of concentration, in consultation with a designated advisor in the field, by submitting a Concentration Proposal Form no later than the end of the first week of classes in the second term of junior year. Concentration requirements are set by each field and consist of either three or four subjects. One of the subjects that counts toward the distribution may also be designated as a concentration subject with the permission of the concentration advisor. Upon completion of all of the subjects noted on the Proposal Form, each student should submit a Concentration Completion Form no later than the end of the first week of classes of the final term prior to graduation. For more information, visit the HASS Requirement website at http://web.mit.edu/hassreq/.

Currently, the following fields of concentration are offered:

- African and African Diaspora Studies
- American Studies
- Ancient and Medieval Studies
- Anthropology
- Archaeology and Archaeological Science
- Art, Culture and Technology
- Asian and Asian Diaspora Studies
- Comparative Media Studies
- Development Economics
- Economics
- Ethics
- Foreign Languages and Literatures (Chinese, ELS, French, German, Japanese, Portuguese, Spanish, Studies in International Literature and Cultures, Theory of Languages)
- History
- History of Architecture and Art
- Latin American and Latino Studies
- Linguistics
- Literature
- Middle Eastern Studies
- Music
- Philosophy
- Political Science
- Psychology
- Religious Studies
- Russian and Eurasian Studies
- Science, Technology, and Society

Theater Arts
Urban Studies
Women's and Gender Studies
Writing

In individual cases, a special concentration may be arranged with advance approval. For more information, visit the HASS Requirement website at http://web.mit.edu/hassreq/.

Electives. The remainder of the eight-subject requirement, above and beyond the Distribution and Concentration, may be fulfilled by subjects from any distribution category or by subjects that are designated as HASS electives.

HASS Information. For detailed information on distribution subjects and on the concentration requirements in any field, and for assistance with any aspect of the Humanities, Arts, and Social Sciences Requirement, including petitioning for a substitution, visit the HASS Requirement website at http://web.mit.edu/hassreq/. Students may also contact the Office of the HASS Requirement (hassreq@mit.edu) to discuss their individual circumstances.

HASS Distribution Subjects

For Classes That Entered in Academic Year 2010–2011 or Thereafter

Classes that entered MIT during the 2010–2011 academic year or thereafter must take one subject in each of the following categories: Humanities, Arts, and Social Sciences. Over 600 subjects may be used to fulfill this requirement. For a complete list of the subjects in each category, consult the online subject listing and schedule (http://student.mit.edu/catalog/index.cgi). Students wishing to enroll in a limited enrollment subject listed as a HASS-D should refer to the section below for information on the HASS-D Lottery.

For Classes That Entered prior to Academic Year 2010–2011

Students who entered MIT prior to fall 2010 and transfer students who entered MIT during academic year 2010–2011 must take three distribution (HASS-D) subjects from three different categories listed below. Each category consists of subjects that are appropriate for students who may never take another subject in that area of learning, and the five categories together offer a range of choices suited to the different interests, abilities, and preparations of MIT undergraduates.

HASS-D subjects have limited enrollment that is managed through the HASS-D Lottery. Students who do not get their first choice HASS-D in the HASS-D Lottery are guaranteed a spot in the subject the next time it is offered, but they must contact the HASS academic administrator in the SHASS Dean’s Office in order to exercise this option. All other students enter their preference for HASS-D subjects into a computerized lottery system prior to each term in order to be assigned to subjects. For details, see http://shass.mit.edu/undergraduate/hass/lottery/.

Language Option. Because the Institute regards competence in foreign language as a fundamental value, a student may substitute one language subject at level III or IV for one HASS-D subject. The two remaining HASS-D subjects may be taken from any two categories.

The current HASS-D subjects, listed by category areas, are as follows:
Category 1: Literary and Textual Studies
This category consists of subjects devoted to the interpretation of texts, to literary traditions, and to genres.

21F.311 Introduction to French Culture
21F.716| Introduction to Contemporary Hispanic Literature and Film
21L.003 Reading Fiction
21L.004 Reading Poetry
21L.006 American Literature
21L.007 World Literatures
21L.009 Shakespeare
21L.012 Forms of Western Narrative
21L.019| Introduction to European and Latin American Fiction [21F.010J]
21L.421 Comedy
21L.522 International Women’s Voices [21F.022], WGS.141J
21L.616| Introduction to Contemporary Hispanic Literature and Film [21F.716J]
21W.735 Writing and Reading the Essay
21W.775 Writing about Nature and Environmental Issues

Category 2: Language, Thought, and Value
Subjects in this category focus on the study of concepts, principles, and modes of expression basic to our efforts to understand individuals and their place in the universe.

21F.059 Paragons of European Thought and Culture
21L.001 Foundations of Western Culture: Homer to Dante
21L.002 Foundations of Western Culture: The Making of the Modern World
21L.017 The Art of the Probable
21L.448| Darwin and Design [21W.739J]
21W.742| Writing about Race [WGS.233J]
21W.747 Rhetoric
24.00 Problems of Philosophy
24.01 Classics of Western Philosophy
24.02 Moral Problems and the Good Life
24.04| Justice [17.003J]
24.06| Bioethics [STS.006J]
24.08| Philosophical Issues in Brain Science [9.48J]
24.09 Minds and Machines
24.90 Introduction to Linguistics
STS.011 Ethics and Politics in Science and Technology

Category 3: Visual and Performing Arts
Subjects in this category are drawn from music, the visual arts, drama and dance, and film. Some are historical and analytical; others are more directly concerned with the creation of art.

4.301 Introduction to Visual Arts
4.601 Introduction to Art History
4.602 Modern Art and Mass Culture
4.605 Introduction to the History and Theory of Architecture
4.614 Religious Architecture and Islamic Cultures
21L.005 Introduction to Drama
21L.011 The Film Experience
21L.016 Learning from the Past: Drama, Science, Performance
21M.011 Introduction to Western Music
21M.013| The Supernatural in Music, Literature, and Culture [21A.20|{L.013J]
21M.030 Introduction to World Music
21M.065 Introduction to Musical Composition
21M.223 Folk Music of the British Isles and North America [21L.423J]
21M.226 Jazz
21M.301 Harmony and Counterpoint I
21M.611 Foundations of Theater Practice

Category 4: Cultural and Social Studies
Subjects in this category study human societies by examining forms of social, cultural, economic, political, and religious organization and behavior.

3.986 The Human Past: Introduction to Archaeology
11.002| Making Public Policy [17.30J]
14.72 Capitalism and Its Critics
17.20 Introduction to the American Political Process
17.40 American Foreign Policy: Past, Present, and Future
17.42 Causes and Prevention of War
17.50 Introduction to Comparative Politics
17.55| Introduction to Latin American Studies [21A.130J, 21F.084J]
21A.00 Introduction to Anthropology: Comparing Human Cultures
21A.01 How Culture Works
21A.102 Ethnic and National Identity
21A.301 Disease and Health: Culture, Society, and Ethics
21A.400 The Stakes of International Development
21F.029| Exploring Identity through Asian American Literature [21L.029J]
21F.064 Introduction to Japanese Culture [meets with 21F.592]
21F.592 Introduction to Japanese Culture [meets with 21F.064]
21H.245| Soviet and Post-Soviet Politics and Society: 1917 to the Present [17.57J]
21L.020 Globalization: The Good, the Bad, and the In-Between [21F.076J]
21W.784 Becoming Digital: Writing about Media Change
CMS.100 Introduction to Media Studies
STS.009 Evolution and Society
STS.010 Neuroscience and Society
WGS.101 Introduction to Women’s and Gender Studies
WGS.109 Women and Global Activism in Media and Politics

Category 5: Historical Studies
Subjects in this category study the development of people, institutions, or countries over a considerable period of time.

21F.027 Asia in the Modern World: Images and Representations [meets with 21F.590]
21F.043| Introduction to Asian American Studies: Historical and Contemporary Issues [21H.107J]
21F.590 Asia in the Modern World: Images and Representations [meets with 21F.027]
21H.001 How to Stage a Revolution
Part

University of Massachusetts

undergraduate education

21H.130  The Ancient World: Greece
21H.132  The Ancient World: Rome
21H.134  Medieval Economic History in Comparative Perspective [14,70]
21H.142  The Age of Reason: Europe in the 18th and 19th Centuries
21H.160  Islam, the Middle East, and the West
21H.185  Introduction to Environmental History
21H.226  Riots, Strikes, and Conspiracies in American History [31.015]
21H.228  American Classics
STS.001  Technology in American History
STS.003  The Rise of Modern Science
STS.005  Disease and Society in America
STS.007  Technology in History

Restricted Electives in Science and Technology (REST) Requirement

Through Restricted Electives in Science and Technology (REST) Requirement subjects, students can broaden and deepen the educational foundation in basic science begun in the first-year program and further the understanding of scientific inquiry. These subjects are designed to give students the opportunity to proceed further in areas already studied, or to explore other areas of potential interest.

REST subjects vary 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 characterize professional work in the field. In general, REST subjects are not too specialized, too advanced, or devoted chiefly to instruction in a particular skill. Students typically take REST subjects in the second year, although with the proper prerequisites they may begin taking them in the first year.

Students meet the REST Requirement by taking two subjects from the list below. Of the subjects used to fulfill the requirement, the student can take no more than one in his or her department. However, subjects designated with a J that are offered jointly with another department do not fall under the departmental limitation.

In many cases, subjects required by a Departmental Program for the SB degree are also on the lists of REST and Laboratory Requirement subjects. Thus, students who follow a particular Departmental Program may simultaneously satisfy some part of these requirements.

REST Requirement Subjects

1.00  Introduction to Computers and Engineering Problem Solving
1.018J  Ecology I: The Earth System [7.30]
1.050  Engineering Mechanics I
2.001J  Mechanics and Materials I
2.003J  Dynamics and Control I [1.053]
2.005  Thermal-Fluids Engineering I
2.087  Engineering Mathematics: Linear Algebra and ODEs I
3.012  Fundamentals of Materials Science and Engineering
3.021  Introduction to Modeling and Simulation [1.021,10.333, 22.00]
3.046  Thermodynamics of Materials
4.42L  Fundamentals of Energy in Buildings [1.044], 2.66]
4.440L  Building Structural Systems I [1.056]
5.07J  Biological Chemistry I [20.507]
5.12  Organic Chemistry I
5.60  Thermodynamics and Kinetics
5.61  Physical Chemistry
6.00  Introduction to Computer Science and Programming
6.002  Circuits and Electronics
6.04J  Probabilistic Systems Analysis
6.042J  Mathematics for Computer Science [18.062]
6.071J  Electronics, Signals, and Measurement [22.071]
7.03  Genetics
7.05  General Biochemistry
8.03  Physics III
8.04  Quantum Physics I
8.20  Introduction to Special Relativity
8.21  Physics of Energy
8.282J  Introduction to Astronomy [12.402]
8.286  The Early Universe
9.01  Introduction to Neuroscience
10.301  Fluid Mechanics
12.001  Introduction to Geology
12.002  Physics of the Terrestrial Planets
12.003  Physics of the Atmosphere and Ocean
12.102  Environmental Earth Science
12.400  The Solar System
12.425  Extrasolar Planets: Physics and Detection Techniques
14.30  Introduction to Statistical Method in Economics
16.001  Unified Engineering I
18.03  Differential Equations
18.034  Differential Equations
18.036  Differential Equations
18.05  Introduction to Probability and Statistics
18.06  Linear Algebra
18.700  Linear Algebra
20.110J  Thermodynamics of Biomolecular Systems [2.772]
22.01  Introduction to Nuclear Engineering and Ionizing Radiation
22.02  Introduction to Applied Nuclear Physics
ESD.03J  System Safety [16.63]

Laboratory Requirement

The Laboratory Requirement (one subject of 12 units or two subjects of 6 units) is met by enrolling in subjects designed for this purpose, and normally is fulfilled in the first two years. The available subjects are listed below.

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

Hypotheses are formulated and then tested by comparing them with the results of the experiments. The student then compares and discusses the experimental results in terms of the current state of knowledge and prepares progress reports and final reports of the work.
The laboratory subjects call for a major commitment of the student’s attention to one or more experimental problems and emphasize as much as possible work of project type rather than routine experimental exercises. The subjects 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, provide broad coverage of a particular field, or complement a specific subject. The laboratory subjects are planned to give each student, at an early stage of his or her educational experience at MIT, an opportunity to work on one or more experimental problems, exercising the same type of initiative and resourcefulness as a professional would in similar circumstances. If the subject is more than 12 units, 12 units will be used to meet the Laboratory Requirement and the additional units will be counted as elective units.

**Laboratory Requirement Subjects**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.01</td>
<td>Introduction to Civil and Environmental Engineering Design I</td>
<td>0-3-3</td>
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<tr>
<td>1.02</td>
<td>Introduction to Civil and Environmental Engineering Design II</td>
<td>1-3-2</td>
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<tr>
<td>1.06</td>
<td>Environmental Fluid Transport Processes and Hydrology Laboratory</td>
<td>0-4-2</td>
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<tr>
<td>1.07</td>
<td>Environmental Chemistry and Biology Laboratory</td>
<td>0-4-2</td>
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<tr>
<td>2.008</td>
<td>Design and Manufacturing II (3-3-6) [gives 6 units of laboratory credit]</td>
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<tr>
<td>2.017</td>
<td>Design of Electromechanical Robotic Systems (3-3-4) [1.015J] [gives 6 units of laboratory credit]</td>
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<tr>
<td>2.671</td>
<td>Measurement and Instrumentation (3-3-6)</td>
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<tr>
<td>2.672</td>
<td>Project Laboratory (0-3-3)*</td>
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<tr>
<td>3.014</td>
<td>Materials Laboratory (1-4-7)</td>
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<tr>
<td>4.411</td>
<td>D-Lab Schools: Building Technology Laboratory (2-3-7) [EC.713]</td>
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<tr>
<td>5.310</td>
<td>Laboratory Chemistry (2-8-2)</td>
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<tr>
<td>5.35</td>
<td>Introduction to Experimental Chemistry (2-8-2)</td>
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<tr>
<td>6.01</td>
<td>Introduction to EECS I (2-4-4) [gives 6 units of laboratory credit]</td>
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<tr>
<td>6.02</td>
<td>Introduction to EECS II (4-4-4) [gives 6 units of laboratory credit]</td>
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<tr>
<td>6.101</td>
<td>Introductory Analog Electronics Laboratory (2-9-1)</td>
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<td>6.102</td>
<td>Introductory RF Design Laboratory (2-9-1)</td>
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<tr>
<td>6.111</td>
<td>Introductory Digital Systems Laboratory (3-7-2)</td>
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<tr>
<td>6.115</td>
<td>Microcomputer Project Laboratory (3-6-3)</td>
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<tr>
<td>6.131</td>
<td>Power Electronics Laboratory (3-6-3)</td>
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<tr>
<td>6.141</td>
<td>Robotics: Science and Systems I (2-6-4) [16.405J]</td>
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<tr>
<td>6.161</td>
<td>Modern Optics Project Laboratory (3-5-4)</td>
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<tr>
<td>6.163</td>
<td>Strobe Project Laboratory (2-8-2)</td>
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<td>6.173</td>
<td>Multicore Systems Laboratory (3-8-1)</td>
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<td>6.182</td>
<td>Psychoacoustics Project Laboratory (3-6-3)</td>
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<tr>
<td>7.021</td>
<td>Introduction to Experimental Biology and Communication (4-8-6) [10.702J] [gives 12 units of laboratory credit]</td>
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<tr>
<td>8.13</td>
<td>Experimental Physics I (0-6-12) [gives 12 units of laboratory credit]</td>
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<tr>
<td>9.02</td>
<td>Systems Neuroscience Laboratory (2-4-6)</td>
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<tr>
<td>9.12</td>
<td>Experimental Molecular Neurobiology (2-4-6)</td>
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<tr>
<td>9.50</td>
<td>Research in Brain and Cognitive Sciences (0-12-0)</td>
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<tr>
<td>9.591</td>
<td>Laboratory in Psycholinguistics (3-3-6) [24.905]</td>
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<tr>
<td>9.61</td>
<td>Laboratory in Higher-Level Cognition (3-6-3)</td>
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<tr>
<td>9.63</td>
<td>Laboratory in Visual Cognition (3-2-7)</td>
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<tr>
<td>11.188</td>
<td>Urban Planning and Social Science Laboratory (3-6-3)</td>
<td></td>
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<tr>
<td>12.115</td>
<td>Field Geology II (0-18-0) [gives 12 units of laboratory credit]</td>
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<tr>
<td>12.119</td>
<td>Analytical Techniques for Studying Environmental and Geologic Samples (2-6-4)</td>
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<tr>
<td>12.307</td>
<td>Weather and Climate Laboratory (1-4-7)</td>
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<tr>
<td>12.335</td>
<td>Experimental Atmospheric Chemistry (2-4-6) [meets with 12.835]</td>
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<tr>
<td>12.410</td>
<td>Observational Techniques of Optical Astronomy (3-4-8) [8.287] [gives 12 units of laboratory credit]</td>
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<tr>
<td>14.33</td>
<td>Research and Communication in Economics: Topics, Methods, and Implementations (3-4-5)</td>
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<tr>
<td>15.301</td>
<td>Managerial Psychology Laboratory (3-3-9) [gives 12 units of laboratory credit]</td>
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<tr>
<td>16.622</td>
<td>Experimental Projects II (1-7-4)</td>
<td></td>
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<tr>
<td>16.821</td>
<td>Flight Vehicle Development (2-10-6) [gives 12 units of laboratory credit]</td>
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<tr>
<td>16.831</td>
<td>Space Systems Development I (2-10-6) [12.431] [gives 12 units of laboratory credit]</td>
<td></td>
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<tr>
<td>17.871</td>
<td>Political Science Laboratory (3-6-6) [gives 12 units of laboratory credit]</td>
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<tr>
<td>18.821</td>
<td>Project Laboratory in Mathematics (3-6-3)</td>
<td></td>
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<tr>
<td>20.109</td>
<td>Laboratory Fundamentals in Biological Engineering (2-8-5) [gives 12 units of laboratory credit]</td>
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<tr>
<td>22.09</td>
<td>Principles of Nuclear Radiation Measurement and Protection (2-6-4)</td>
<td></td>
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<tr>
<td>24.909</td>
<td>Field Methods in Linguistics (3-1-8)</td>
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</tbody>
</table>

**Physical Education Requirement**

The mission of the Physical Education Program is to provide learners with the instruction and skills necessary to lead healthy, active lifestyles and to foster both personal growth and a sense of community through physical activity. The program enables students to engage in physical activity while they are involved in rigorous academic study. Major emphasis is placed on the development of skills that can be used for lifetime fitness and wellness. Students receive a strong background in the fundamentals of the activity selected. Instruction is offered in fitness, wellness, individual and team sports, martial arts, dance, aquatics, and outdoor adventure activities. Information on classes, including descriptions of current offerings, is available at http://mitpe.com/.

To satisfy the Physical Education Requirement undergraduates entering MIT as freshmen must take four physical education courses (for eight points) and complete the swimming requirement. Transfer students need to complete four points (two courses) as well as the swimming requirement. A student may repeat a course at any level and receive points. The swimming requirement can be satisfied by taking a beginning swim class or students may elect to test out on fall registration day (visit http://mitpe.com/ to see a video of the swim test). In addition to taking traditional physical education courses, students may earn physical education points in the following ways:
Varsity sports: Four points are awarded to players for each year of competition.

ROTC Programs (Air Force, Army, Navy): Two points are awarded per year of ROTC participation up to a maximum of four points.

Approved personal training, private swim lessons, and group exercise classes offered through the Department of Athletics, Physical Education, and Recreation.

Students find it best to complete their four courses during their freshman year; however, students are responsible for completing their Physical Education Requirement by their sophomore year. In general, students must attend 11 sessions/classes to receive the two points for a physical education course. Freshmen are expected to complete the swim test on fall registration day or, if they can’t swim, register during the swim test for a first-quarter swim course. Students who do not complete the Physical Education Requirement by the end of their sophomore year must submit a plan for a time extension with the Physical Education Office at http://mitpe.com/.

Physical education courses are offered in two six-week quarters during the fall term and during the spring term. A fifth “quarter” is offered during the January Independent Activities Period. Two points are awarded for each course per quarter.

Physical education registration is open to undergraduates and graduate students. Registration is conducted online at http://mitpe.com/. Information on registration can be obtained through WebSIS at http://student.mit.edu/. Registration dates are posted in the Academic Calendar as well as at http://mitpe.com/.

Physical education courses offered last year included Group Exercise (Boot Camp for Athletes, Kickboxing, Pilates, PiYo, Step, Yoga), Archery, Backpacking/Hiking, Badminton, Basketball, Broomball, Cross-Country Ski, Dance (Tango, Salsa, Square), Fencing, Figure Skating, Flag Football, Golf, Gymnastics, Hockey, Ice Hockey, Kayaking, Pistol, Rifle, Ropes Adventure, Running/Jogging, Sailing, SCUBA, Self Defense, Sport Taekwondo, Skating, Skiing/Snowboarding, Soccer (indoor), Squash, Tennis, Top Rope Climbing, Ultimate Frisbee, Volleyball, and Weight Training.

Students must wear appropriate attire for activity classes. Most classes provide all necessary equipment. Students must supply sticks for ice hockey courses. Non-marking court shoes are required for squash and tennis. Lab fees are required for some courses. Undergraduate and graduate students must activate their MIT ID card annually to gain access to all sport facilities.

For further information contact the Physical Education Office, Room W35-297X, 617-253-4291, mitpe@mit.edu, or visit http://mitpe.com/.

ACADEMIC AND RESEARCH OPTIONS

Independent Activities Period

Independent Activities Period (IAP) is a four-week period in January during which faculty and students are freed from the rigors of regularly scheduled classes for flexible teaching and learning and for independent study and research. IAP is part of the academic program of the Institute—the “1” month in MIT’s “4-1-4” academic calendar. Students are encouraged to explore the educational resources of the Institute by taking specially designed subjects, arranging individual projects with faculty members, or organizing and participating in IAP activities. They may also pursue interests independently either on or off campus.

Departmental programs may require students to complete a subject (of no more than 12 units) during one IAP.

Activities

More than 600 activities are offered each year on a wide range of topics, both academic and nonacademic. In addition, “special subjects” exist in most departments, for which students can arrange credit for individual work.

Many IAP activities, both credit and noncredit, are organized each fall. They are advertised, beginning in early November, on the IAP website at http://web.mit.edu/iap/.

Organizing Activities

Nonacademic activities may be organized or attended by members of the MIT Community: faculty, students, and employees. Tips on organizing an IAP activity are available on the web at http://web.mit.edu/iap/.

Organizers may approach MIT departments and organizations to help defray expenses.

Students find organizing IAP activities a rewarding challenge. For many, it is their first opportunity to develop and teach a program from their own ideas. In doing so, they acquire organizational and leadership skills that prove invaluable to their careers.

Tuition, Room, and Board

Regular students paying full tuition in either the fall or spring term do not have to pay additional tuition or room fees to the Institute during IAP. MIT Dining provides food service options through retail, house dining, and catering services throughout the entire academic year, including IAP. (The regular meal plan program does not include IAP, but students may pay the cash door price). For operating hours and locations, visit http://dining.mit.edu/. Students who have not been charged full tuition in either the fall or spring term are subject to additional tuition charges and should consult the Registrar’s Office, Room 5-119, 617-258-6409.

Academic Credit and Grades

Students should follow directions published on MIT’s IAP website at http://web.mit.edu/iap/ regarding registration for subjects. In addition to the organized subjects, students may make arrangements to earn credit for independent work under faculty supervision. The total credits a student can earn during IAP is limited to 12 credit units. Credits received by freshmen during IAP are not counted toward their credit limits for the spring or fall term.

All credit-bearing subjects during IAP are to be graded following the grading system approved for that subject number. A subject can be graded P/D/F during IAP only if it has been approved with P/D/F grading. Similarly, the number of units awarded must be as specified for that subject. Faculty sometimes offer newly organized credit activities under special problem subject numbers for which credit units are “to be arranged.”
In order for students to receive credit for work done in IAP, grades must be submitted to the Registrar’s Office by the deadline at the end of IAP given in the academic calendar. If a grade is received after the Add Date of the succeeding term and the student did not register in the subject during IAP, the student must petition in order to receive credit. IAP credit will not be given if the grade is received after the end of the succeeding spring term.

Students may view their IAP grades on WebSIS shortly after the start of the spring term. Students who do not receive grades when expected should check promptly with their instructors or the Registrar’s Office to ensure the grades are submitted and recorded.

Special Students
Applications for special student status solely for IAP will not be accepted. Special students admitted to the fall or spring term must consult the Admissions Office concerning their status during IAP; they do not automatically have IAP privileges. If the special student has paid full tuition during the fall term or is admitted to do so in the spring, there will not be an additional tuition charge for IAP. If the student has not been paying full tuition, a charge for the IAP units will be added to either the fall or spring term up to a maximum of full tuition for the term.

Undergraduate Research Opportunities Program
The Undergraduate Research Opportunities Program (UROP) invites undergraduates to participate in a wide range of research activities that are available in every academic department and most interdisciplinary laboratories and centers in collaboration with MIT faculty.

There are many advantages to becoming involved in such pursuits as early as possible in an undergraduate career: establishing ties to faculty, investigating a potential major, acquiring data-gathering and laboratory techniques, exploring the frontiers of a field, undertaking topics not amenable to the classroom, facing a real-world problem, and establishing a focus for educational experiences. Through UROP, students may gain a better understanding of the intellectual process of inquiry, while having the opportunity to experience personal and professional growth. Students may earn pay or academic credit, or may work on a volunteer basis. Whatever the chosen mode, all UROP work is expected to be worth academic credit.

Guidelines for participating are available online at [http://web.mit.edu/urop/](http://web.mit.edu/urop/). This website lists UROP contacts for Institute departments, laboratories, and centers. While these people are prepared to assist students, a certain amount of footwork and negotiation is required to achieve a satisfying collaboration. The UROP experience is unlike any other; its benefits and rewards are great, but expectations and standards are commensurate. For advice and assistance, contact UROP staff in the Office of Undergraduate Advising and Academic Programming, Room 7-104, 617-253-7306, fax 617-253-8816, urop@mit.edu.

Freshman Advising Seminars Program
The Freshman Advising Seminars (FAS) program is available only to first-term freshmen through an online application. Freshman Advising Seminars are one option for freshman advising. A Freshman Advising Seminar is typically led by a faculty member who also serves as the freshman advisor to the small group of seminar advisees. While FASes vary in style and topic, most are oriented to group discussion and offer an opportunity to interact closely with faculty. All Advising Seminars receive six units of credit and are graded P/D/F.

Information about the Freshman Advising Seminars program, including titles, descriptions, and application information for incoming freshmen, can be found at [http://web.mit.edu/firstyear/](http://web.mit.edu/firstyear/). This website is maintained by the Office of Undergraduate Advising and Academic Programming, Room 7-104, 617-253-6771, firstyear-www@mit.edu.

Interphase EDGE
Interphase EDGE (Empowering Discovery, Gateway to Excellence) is a two-year scholar-enrichment program that includes a seven-week summer session as well as programming during the academic year. The focus of the summer program is to give scholars an introduction to the MIT experience by exposing them to the rigors of a full subject load and to life on campus.

In addition, the Interphase EDGE curriculum is uniquely designed to impart pivotal concepts that will increase long-term academic success. The program is designed not only to give students an “edge” on their MIT experience, but also to catalyze their successes beyond MIT. During the summer and academic year, scholars will participate in a range of personal and educational development seminars and activities designed to ensure their smooth transition to college life. Throughout the academic year, scholars will continue to build upon the relationships created during the summer by attending biweekly meetings with EDGE advisors and monthly professional and academic enhancement events, including programs that expose them to various career pathways.

For more information, contact the Office of Minority Education at 617-253-5010 or visit [http://ome.mit.edu/programs-services/interphase-edge-empowering-discovery-gateway-excellence/](http://ome.mit.edu/programs-services/interphase-edge-empowering-discovery-gateway-excellence/).

Edgerton Center
The Edgerton Center offers an ever-widening variety of courses for both undergraduate and graduate students, and provides resources and opportunities for students to pursue hands-on projects, UROPs, and other activities.

Named for Professor Harold Edgerton, whose high-speed photography legacy lives on with the Strobe Alley exhibition of Edgerton photographs, the center can provide a workplace, test equipment, access to the Student Machine Shop, or simply advice and encouragement. The laboratory, classroom, and studio are located in Strobe Alley on the fourth floor of Building 4. For more information on using facilities, contact Jim Bales at bales@mit.edu or Amy Fitzgerald at amyfitz@mit.edu.

The Student Shop is located in Room 44-023 and offers regular training sessions for use of CNC mills, lathes, a 3D printer, and more. Contact manager Mark Belanger at mdbelang@mit.edu for access and training.

Subjects offered include introductory electronics, digital photography, and classes in international development (see D-Lab classes below). In addition, Doc Edgerton’s Strobe Project Laboratory is taught each term by assistant director Jim Bales. A listing of the subjects offered can be found at [http://web.mit.edu/Edgerton/www/Courses.html](http://web.mit.edu/Edgerton/www/Courses.html).

International development is a growing area of interest for students and faculty, and is a key part of MIT’s goal of advancing global education. The International Development Initiative (IDI) contributes to the vibrant international development ecosystem at MIT. IDI aims to serve the MIT com-
community through four core functions: programs, mentoring, get involved, and networking.

D-Lab is a program that fosters the development of appropriate technologies and sustainable solutions within the framework of international development. There are currently several different academic offerings that make up the suite of D-Lab classes, falling into the broad categories of development, design, and dissemination. For more information about D-Lab, visit http://d-lab.mit.edu/ or contact Elisha Clark at eliclark@mit.edu.

The Edgerton Center Outreach Program gives MIT students an on-campus opportunity to teach engineering and science to 4th through 8th graders from area schools. Topics include mechanical engineering, circuits, optics, biology, and more. Contact Amy Fitzgerald at amyfitz@mit.edu or 617-324-4887.

The center also supports a range of hands-on student activities, including the Solar Electric Vehicle Team, Formula SAE, the Marine Robotics Team, and a variety of other engineering groups. Students interested in starting up a new team should contact Steven Banzaert, sgtist@mit.edu.

Team, and a variety of other engineering groups. Students interested in

Grading Options
Grading options are intended to provide students with the opportunity to explore new and challenging subjects and to broaden their educational experience with reduced effect on term and cumulative ratings. These options must be approved by the student’s advisor and designated by Add Date.

Sophomore Exploratory. Sophomores may designate one subject as exploratory in each of their fall and spring terms. An exploratory subject is one in which the student may either accept the grade awarded in the subject or change the subject to listener status through Registration Day of the succeeding term. Students receive no credit for listener subjects, which do not appear on transcripts. Any subject may be designated as exploratory—including an Institute, departmental, or minor requirement or a cross-registered subject taken at another school.

Junior-Senior P/D/F. A student may take a total of two subjects to be graded P, D, or F during his or her junior and senior years, where P indicates C or better performance (C- with modifier used within MIT). Such subjects may not be used to fulfill the General Institute Requirements or departmental or minor requirements. However, the subjects will count in the units completed beyond the General Institute Requirements.

Study at Other Universities
There are a number of opportunities for MIT undergraduates to study at other universities, including study abroad, domestic study away, and cross-registration programs with local universities. Students who spend a term or a year studying abroad or at another US university find that in addition to the intellectual benefit, they are enriched by day-to-day exposure to different cultural and/or social experiences. Through the cross-registration programs students may take subjects not offered at MIT.

Study Abroad Opportunities
Cambridge-MIT Exchange Program
Through the Cambridge-MIT Exchange Program (CME), undergraduate MIT students can spend their junior year studying at the University of Cambridge in England.

Founded in 1209, the University of Cambridge consists of 31 self-governing colleges where students live and study in a supportive educational environment. Lectures, laboratories, and project work are organized by the university; the colleges organize small-group sessions (“supervisions”) designed to complement the lectures. In addition to teaching, research is of major importance at Cambridge. Since the beginning of the 20th century, more than 60 members of the University of Cambridge have won Nobel Prizes.

MIT students who study for a year at Cambridge receive sufficient transfer credit to permit normal progress toward their MIT degree. Participating departments include Aeronautics and Astronautics; Biology; Brain and Cognitive Sciences; Chemical Engineering; Chemistry; Civil and Environmental Engineering; Earth, Atmospheric and Planetary Sciences; Economics; Electrical Engineering and Computer Science (including Course 6-3); History; Materials Science and Engineering; Mathematics; Mechanical Engineering; and Physics.

While on the exchange, MIT students pay tuition to MIT; they are billed at Cambridge for the costs of room and board only. While away at Cambridge during the fall and spring semesters, a student maintains full-time student status at MIT.

Interested students should discuss their plans with CME faculty coordinators in the departments as early as possible. For further information, students should contact Sarra Shubart, program coordinator, 617-253-6057, sarra@mit.edu, or their departments. A list of CME faculty coordinators and administrators in each department can be found at http://gecd.mit.edu/go_abroad/study/explore/cme/start/.

MIT-Madrid Program
The MIT-Madrid Program gives students the opportunity to study in Madrid for the spring term during their sophomore or junior year. Depending upon major and interests, students can choose science and engineering courses at the Universidad Politécnica de Madrid and/or humanities, arts, and social sciences courses at the Universidad Complutense de Madrid; instruction and coursework are in Spanish. These are leading universities in Spain, each with its distinguished tradition and history. In addition to academic courses, students can participate in an internship during this program. Students who plan to participate must be in good academic standing and have taken Spanish IV at MIT or its equivalent. MIT-Madrid Program participants are placed individually with Spanish families in homestays. For more information visit http://gecd.mit.edu/go_abroad/study/explore/madrid/.

IAP-Madrid Program
The IAP-Madrid Program is a Spanish II language program open to MIT undergraduate and graduate students. This is an MIT course taught by an MIT faculty member. For more information contact Global Education, Room 12-189, studyabroad@mit.edu.
MISTI
MIT International Science and Technology Initiatives (MISTI), though primarily an international internship program (see below), also facilitates study abroad opportunities for students through one of its 14 country programs. Opportunities include semester-long programs with prestigious institutions such as École Polytechnique and Sciences Po in France, and Ben Gurion University of the Negev, Haifa University, Hebrew University, Technion-Israel Institute of Technology, and Tel Aviv University in Israel. For more information, visit http://web.mit.edu/misti/.

Departmental Exchange Programs
The Department of Aeronautics and Astronautics offers study at the University of Pretoria in South Africa. For more information contact Global Education, Room 12-189, studyabroad@mit.edu.

The Department of Architecture has two exchange programs, one with Delft University of Technology in the Netherlands and the other with the University of Hong Kong. For more information visit http://architecture.mit.edu/undergraduate-foreign-exchange.html.

The Department of Materials Science and Engineering has an exchange program with Oxford University. For more information contact Professor Linn Hobbs, 617-253-6835, hobbs@mit.edu.

The Department of Political Science and Program in Science, Technology, and Society are starting an exchange program with Sciences Po in Paris, France. For more information, contact Global Education, Room 12-189, studyabroad@mit.edu.

Other Study Abroad Options
MIT students may also apply for admission directly to foreign institutions that offer study abroad programs or to a study abroad program administered by another US institution or a study abroad provider. Examples of such opportunities include study at l’École Polytechnique in France, a year-long or summer program at the London School of Economics, and programs at Australian universities. To explore these options, and many other exciting opportunities around the world, schedule an appointment with a staff member in Global Education, Room 12-189, studyabroad@mit.edu.

Numerous institutions offer programs abroad taught in English. It is possible to study in a foreign country without prior knowledge of the host country’s language. However, a working command of the language can add greatly to the overseas experience. Even a student without prior language skills can usually achieve a good level of proficiency in a foreign language by the beginning of the junior year if he or she begins language study by spring term of freshman year.

With proper planning and preparation, students who successfully complete an approved program of study abroad receive transfer credit toward their MIT degree. While at the host institution, students must arrange to have an official transcript sent directly to the MIT Registrar’s Office showing coursework and final grade(s) completed at the outside institution. Upon return, they must submit a completed Request for Additional Credit Form, signed by the appropriate transfer credit examiner(s).

For further information, contact Global Education, Room 12-189, 617-253-6057, studyabroad@mit.edu, or visit http://gecd.mit.edu/go_abroad/.

Domestic Study Away
Students may choose to spend from one term to one year studying at another academic institution within the US. Students studying at another US university usually pay tuition to the outside institution rather than to MIT. While on an approved domestic study away program during the fall and/or spring term(s), students maintain full-time student status at MIT. Students interested in domestic study away should make an appointment with a staff member in Global Education, 12-189, studyabroad@mit.edu.

To qualify for Domestic Year Away status, students must show that their proposed program of study draws upon resources available at the outside institution that are not generally available at MIT, or at the institutions with which MIT has cross-registration privileges. In addition, a planned program of study should be consistent with an overall degree program at MIT. Students must be accepted by a school of established academic merit and undertake a workload comparable to that at MIT. Students planning to spend time studying at another academic institution in the US need to work out their plans with a faculty advisor and appropriate transfer credit examiner(s) and must complete a Worksheet for Planning Study Abroad/Domestic Study Away (http://gecd.mit.edu/go_abroad/study/prepare/).

With proper planning and preparation, students who successfully complete an approved program of study at another US university receive transfer credit. While at the host institution, students must arrange to have an official transcript sent directly to the MIT Registrar’s Office showing coursework and final grade(s) completed at the outside institution. Upon return, they must submit a completed Request for Additional Credit Form, signed by the appropriate transfer credit examiner(s).

For further information, contact Global Education, Room 12-189, studyabroad@mit.edu or visit http://gecd.mit.edu/go_abroad/.

Cross-registration Programs
Subjects taken through cross-registration programs with Harvard and Wellesley may be used to fulfill departmental major and minor requirements with the permission of a faculty advisor.
When appropriate, cross-registration subjects taken for a letter grade at Harvard and Wellesley may count toward fulfillment of the HASS Requirement; in most cases, students must submit a petition to the Subcommittee on the HASS Requirement. Subjects may be designated as part of the Concentration for the Humanities, Arts, and Social Sciences at the discretion of the designated advisor in that field of concentration.

Harvard University
MIT undergraduates are permitted to take subjects at Harvard University (except Harvard Extension School, Harvard Summer School, and Harvard Summer School) for degree credit at no extra charge. This cooperative arrangement is not applicable to the summer session. In general, MIT students take subjects at Harvard which are not offered regularly at MIT. Cross-registration is limited to upperclass students who must be regularly enrolled at MIT and paying full tuition for the term in question. No more than half of a student’s registration (up to a maximum of 24 units) may be taken at Harvard in any one term.

Arrangements are made through the School of Humanities, Arts, and Social Sciences Dean’s Office, Room 4-240. When appropriate, Harvard subjects can count toward fulfillment of the HASS Requirement; in most cases, students must submit a petition to the Subcommittee on the HASS Requirement. Letter grades earned in Harvard subjects appear on the transcripts of MIT undergraduates. Detailed information about the Harvard cross-registration option for undergraduates is available at http://web.mit.edu/shass/undergraduate/programs/cross-reg.shtml.

Wellesley College
MIT students may cross-register for any courses at Wellesley if they present the necessary prerequisites. This exchange program is not applicable to IAP or the summer session. Wellesley is a small, liberal arts college for women located on a 500-acre campus 17 miles west of Cambridge.

Through the Wellesley Education Department, MIT students may earn Massachusetts certification to teach at the elementary or high school level. This certification is recognized by many other states.

Students generally cannot substitute Wellesley subjects for MIT Science Requirement subjects (Chemistry, Biology, Physics, and Calculus) or Institute Laboratory Requirement subjects. They may take Wellesley subjects to satisfy Restricted Electives in Science and Technology (REST) Requirements, but need the approval of the Committee on Curricula.

When appropriate, Wellesley subjects can count toward fulfillment of the HASS Requirement; in most cases, students must submit a petition to the Subcommittee on the HASS Requirement.

Wellesley subjects may be used to fulfill departmental major and minor requirements with the permission of a faculty advisor.

For upperclass students, letter grades will be recorded for Wellesley subjects, unless the student designates a Wellesley subject as one of his or her two electives to be graded P, D, or F. Grades for freshmen will be converted to the MIT first-year grading system.

Students may take physical education classes at Wellesley on a space-available basis and may apply these classes toward their MIT physical education requirements. MIT students receive full library privileges at the Wellesley College Library.

Wellesley operates free weekday bus service between the two campuses. The service is open to everyone with an MIT or Wellesley identification card, but priority will be given to cross-registered students. The ride is about 50 minutes each way.


Massachusetts College of Art and Design and the School of the Museum of Fine Arts
MIT undergraduates may cross-register at the Massachusetts College of Art and Design (MassArt), a state college, and the School of the Museum of Fine Arts (SMFA), a private school affiliated with the Museum of Fine Arts Boston. Both are highly respected art schools in Boston with studio classes such as drawing, painting, and printmaking that are not offered for credit at MIT.

Classes taken at MassArt and SMFA through the cross-registration program are graded P, D, or F and may not be used to satisfy Institute, departmental, or minor requirements. They may be used toward unrestricted elective credit. Only one subject from either school may be taken in a semester. This program is not applicable to IAP or the summer session.

Students must complete a cross-registration form, available in the Student Services Center, Room 11-120, by the deadline set by the MIT Registrar. Detailed information is available at http://visualarts.mit.edu/about/xreg_art.html.

Internships Abroad
Each year, hundreds of MIT students gain international experience by interning at premier corporations, universities, and research institutes abroad. MIT International Science and Technology Initiatives (MISTI) offers internship and research opportunities in Brazil, Chile, China, France, Germany, India, Israel, Italy, Japan, Korea, Mexico, Russia, Singapore, and Spain. To help make an international experience available to every MIT student, MISTI internships are all-expenses-paid and open to undergraduates, graduate students, and recent grads. Internships range from three months to one year, with opportunities available for every major. MISTI sends over 600 students abroad each year. For more information, see the description of the Center for International Studies in Interdisciplinary Research and Study in Part 3 or visit http://web.mit.edu/misti/.

Global Education and Career Development
Global Education and Career Development (GECD) empowers MIT students and alumni to achieve lifelong success through seamless access to significant global experiences, comprehensive and holistic career services, and mutually beneficial connections with employers and graduate schools. It accomplishes this through four primary programs:

- Career Planning and Preparation
- Prehealth Advising
- Global Education
- Employment Recruitment Services
Through career planning and preparation programs students learn to make informed career decisions and find opportunities related to their professional objectives. Students are encouraged to begin their career education early, including meeting with a counselor, located in Career Services, Room 12-370, and visiting http://gecd.mit.edu/ to learn about available resources. Career development is an ongoing process that includes self-assessment, competency development, research into career options, experiential learning, and preparation for the job search or for the graduate/professional school application process.

These programs help undergraduate and graduate students explore and learn about:

- The relationship between what they are doing at MIT and life after graduation
- Life skills required to succeed in the competitive global marketplace and to contribute to society
- Career options in relation to choice of major
- Internships, externships, global opportunities (including study abroad), fellowships, and other experiential learning opportunities
- Writing a resume and cover letter, networking with alumni and industry professionals, conducting informational and formal interviews, negotiating salary, and participating in career fairs
- Finding employment after graduation

Admitted pre-freshmen can apply for the Freshman/Alumni Summer Internship Program, a 6-unit graded seminar (SP.800/SP.801) that offers career development training. The program accepts 100 students each year; applications are accepted on a first-come, first-served basis from June 1 through August 14 of the summer prior to matriculation at MIT.

Prehealth Advising, part of GECD and located in Room 12-185, supports students interested in exploring and applying to health professional schools. There is no required major for admission to health professional schools; however, schools do require applicants to complete a number of science and writing subjects prior to admission. Students should visit http://gecd.mit.edu/grad_school/health/ for information on admissions criteria, the application process, and services provided.

Global Education (Room 12-189) is a one-stop office for information on all MIT global education opportunities, helping students to investigate and prepare for global opportunities that best fit their academic and life interests as well as to integrate the global experience into their life at MIT and career. The team also provides expertise and consultation to faculty and program directors regarding study abroad and other global opportunities. It offers comprehensive support to undergraduates interested in and preparing for study abroad, and works with partner programs such as the UROP Office, the Public Service Center, and MITi to support other opportunities. It also provides support and guidance to students preparing applications for distinguished fellowships, including but not limited to the Rhodes, Marshall, Mitchell, Gates, and Fulbright fellowships. For further information, see the section on Academic and Research Options in this chapter.

The employment recruiting program provides students with opportunities for internships, summer jobs, and full-time positions after graduation. Hundreds of employers recruit students through a password-protected recruitment management system and on-campus recruiting visits. Many employers also host presentations and participate in career fairs, which provide the opportunity for students at any stage in their academic program to discuss employment prospects and find out about careers at different organizations.

For further information, contact Global Education and Career Development, Rooms 12-189 (Global Education), 12-170 (Career Services), or 12-185 (Prehealth Advising), or call 617-253-4733, fax 617-253-8457, or visit http://gecd.mit.edu/.

Teacher Training and Education

Options for MIT students interested in teaching elementary or secondary school range from exploratory activities such as tutoring and UROP activities to formal certification programs.

For students who wish to explore teaching as a career (in the short or long term), the MIT/Wellesley Scheller Teacher Education Program (STEP), housed in the Department of Urban Studies and Planning, provides the requirements for Massachusetts State Teacher Certification in math and science at the middle and high school levels (and can be transferred to many other states). Courses offered through the STEP are also useful for students preparing to teach at the college level, as well as those who wish to apply their work to related research fields such as curriculum design or educational technology. Those going into industry find that the STEP can contribute to work in advancing educational programs, as well as work on human-computer interface and software development.

Education subjects that focus on math/science teaching at the secondary level (grades 5-12) are offered through Course 11 Urban Studies and Planning. To receive Massachusetts Teacher Certification, students must complete supervised practice teaching and additional coursework at MIT, or through Wellesley College. A HASS concentration in Urban Studies with emphasis in education is offered as part of the undergraduate curriculum.

For additional information see the STEP home page at http://education.mit.edu/classes/overview/

To explore K-12 teaching opportunities less formally, students may volunteer as tutors or teacher assistants in local schools, offer informal classes through the Educational Studies Program, or work with faculty members who conduct research in schools. (Refer to the UROP Directory for a list of faculty members interested in such research.) The Student Services Center, Room 11-120, and the Public Service Center, Room 3-123, can also provide assistance.

ROTIC Programs

Military training has existed at MIT ever since the Institute opened its doors in 1865. More than 12,000 officers have been commissioned from MIT, of whom more than 350 have reached the rank of general or admiral. Students who are United States citizens or who have applied for citizenship, are of good moral character, and are medically qualified for military service, may enroll in the programs for leadership training. Non-citizens who fulfill naturalization requirements for citizenship prior to graduation may enroll and participate in the four-year nonscholarship programs. Any full-time MIT student may participate in the programs for leadership training.

All three programs—Air Force, Army, and Naval ROTIC—have the following characteristics in common:
• Application is voluntary.
• Admission is selective.
• All admit men and women.
• Enrollment as a nonscholarship freshman or sophomore does not involve a military service obligation.
• Most students enter the program at the beginning of their freshman year. However, entry up to the beginning of the junior year is available.
• To be eligible for a commission as an officer in the Armed Forces, students must complete the Reserve Officers’ Training Corps (ROTC) program, including summer training, and earn their bachelor’s degree.
• Upon request by the student, any required summer employment financial aid contribution can be waived if summer training makes such employment impossible.
• Nonscholarship students may compete for ROTC scholarships, many of which cover full tuition and fees, and range from one to three-and-a-half years for the Army, Air Force, and Navy.
• Enrollment as a scholarship recipient beyond the freshman year generally creates an obligation of four years of active duty service in the Army, Navy, or Air Force, or in some cases, for alternative service in the National Guard or Reserve.

Aerospace Studies (AS), Military Science (MS), and Naval Science (NS) subjects are not included in a student’s grade point average, and the credits do not count toward a degree. These subjects cannot be applied toward the Physical Education Requirement. In some cases, the ROTC programs may include departmentally approved subjects that provide academic credit.

Students who accept a contract to become an officer must maintain acceptable levels of academic performance and physical fitness. ROTC academic performance requirements may exceed Institute standards. Breach or willful evasion of the contract could lead to a period of enlisted service or to repayment of scholarship funds.

Specific information concerning benefits, ROTC training programs, career opportunities, and contractual obligations can be obtained from the program offices listed in this section.

Air Force ROTC
The Air Force ROTC program provides students the opportunity to become commissioned officers in the Air Force after completing their undergraduate or graduate degree. It is designed to develop the leadership and management skills essential for an Air Force officer while preparing the student for assignment in a career field related to his or her academic specialty.

Training Program
The program consists of classroom and leadership laboratory work during the four years of academic study and one summer training period of four weeks between the second and third years at an Air Force base. Students with three academic years remaining may enroll in the four-year program by combining the first two years.

The first two years of the four-year program are known as the General Military Course (GMC). Upon completion of the GMC and summer field training, students may compete for entry into the Professional Officer Course (POC). Selection into the POC is based on academic aptitude and performance, successful completion of the GMC and field training, and recommendation of the professor of Aerospace Studies.

Two-Year Program
The two-year program is for highly qualified students who do not complete the first two years of the four-year Air Force ROTC program. Such students may apply if they have two years remaining in their academic program at MIT. In order to complete the GMC requirement, these students will meet with the instructor to set up an academic plan to make up the GMC. They receive the same benefits and complete the same academic program required of POC members in the four-year program.

Scholarships
Air Force ROTC scholarships are available on a competitive basis to qualified applicants. Scholarships pay up to full tuition, including $900 per year for textbooks, and a $300–500 nontaxable allowance each month. Two- to three-and-a-half year scholarships are offered on a competitive basis in addition to the four-year scholarships offered to high school seniors. The detachment commander also has three-and-a-half year full-tuition scholarships to award to outstanding freshmen (technical majors) and $18,000 per year scholarships to award to non-technical students.

Classroom Instruction
The Aerospace Studies curriculum emphasizes the history, organization, and mission of the Air Force, including its role in national defense strategy and American society. Academic classes and leadership laboratory activities provide training and practical experience in developing leadership and managerial skills.

Students enrolled in the first two years of the program attend one hour of class and two hours of Leadership Laboratory (LLAB). In the final two years of the program, the class time is three hours per week with the same LLAB requirement. LLAB has always been a highlight of the program, introducing cadets to a variety of motivational and interactive activities. Aside from standard drill practice, students participate in guest-speaker events, athletic competitions, self-defense class, marksmanship training, rock climbing, career day, and much more. Cadets must also complete two hours of physical fitness training each week.

Eligibility Requirements
To be eligible for the Air Force ROTC scholarship program and the POC, students must be citizens of the United States; physically qualified in accordance with existing Air Force regulations; and enrolled at MIT, Harvard University, Salem State University, Tufts University, or Wellesley College as full-time students.

Application Procedure
Interested students can sign up for the Air Force ROTC program by visiting the Aerospace Studies Department, Room W59-114, 617-253-4475, airforce@mit.edu.
Army ROTC
The Army ROTC program at MIT is designed to enhance a student's college education by integrating into the curriculum leadership and management theory with leadership practicum modules. Through coursework and in-class practical experience, students will develop decision-making, team-building, and time-management skills—leadership qualities that are essential to success in any field, including corporate or research careers. Students completing the ROTC program earn a commission as a Second Lieutenant in the US Army. Non-scholarship students may participate in the first two years of Army ROTC with no commitment to military service.

The Military Science and Leadership Program is a four-year program composed of the Basic Course (freshman and sophomore years) and the Advanced Course (junior and senior years).

Four-Year Program
The four-year curriculum combines classroom and leadership laboratory work. Any MIT student is eligible to participate in the leadership development courses regardless of academic grade.

During the summer between their junior and senior years, students participate in a four-week Leadership Development and Assessment Course (LDAC) at Fort Lewis, WA (near Seattle). Upon graduation from college and successful completion of LDAC, students are commissioned as officers in the US Army, US Army Reserves, or Army National Guard.

Two-Year Program
The two-year program is designed for students who did not complete the first two years of the Army ROTC program. If students have at least four semesters remaining in their academic program at MIT or are interested in pursuing a graduate degree, they may be eligible to participate in the Advanced Course. Students must participate in a four-week training camp (Leader’s Training Course) at Fort Knox, KY, in lieu of completing the Basic Course (freshman and sophomore years). Once students complete the Leader’s Training Course, they are eligible to receive the same benefits as members in the four-year program.

Scholarships
Army ROTC scholarships are available on a competitive basis to qualified applicants. Two-, three-, and four-year scholarships are available each year, and are awarded on campus through the professor of military science or through a national selection board. High school seniors may apply for four-year scholarships in conjunction with their application to MIT. Scholarships pay full tuition and all mandatory fees, plus $1,200 for books and supplies each year, and a tax-free stipend ranging from $300 to $500 per month. The scholarship is flexible in that it can be used for either tuition and all mandatory fees or for room and board.

Program of Instruction
The Army ROTC curriculum is designed to enhance a student’s college education by providing distinctive leadership and management training in conjunction with realistic experience. The program emphasizes leadership theory and practice, organizational management, public speaking, tactics, purpose and history of the military, and physical fitness.

Students enrolled in the first two years of the program attend one hour of class and three hours of physical fitness each week. Collegiate athletes who meet Army fitness standards are excused from physical fitness training while their sport is in season. In the final two years of the program, class and physical fitness total four to five hours per week. Students also participate in a biweekly Leadership Lab that highlights a particular military activity. Finally, students participate in a field training exercise each semester that includes small unit leadership training, military tactics, land navigation, rappelling, obstacle negotiation, and possibly a helicopter orientation ride.

Extracurricular Events
The ROTC program offers MIT students a wide spectrum of opportunities to participate in numerous challenging and rewarding extracurricular activities, such as high adventure training and field training exercises. Army Airborne, Air Assault, Mountain Warfare, and other military schooling and training programs are available on a voluntary basis to qualified cadets. Also, there are global summer internships available at national research laboratories, numerous Army bases, or the Pentagon. Finally, following graduation there are opportunities—primarily for students going on to law, medical, dental, or veterinary school—to defer the service obligation until completion of their graduate studies. Many graduate study opportunities are funded by the Army.

Opportunities in the US Army Reserve/Army National Guard
Army ROTC offers opportunities to seek a commission as a Second Lieutenant in the Army National Guard or Army Reserves. This unique option provides the flexibility for newly commissioned officers to participate in the Army part time while pursuing an advanced degree or a full-time career.

Eligibility Criteria
Enrollment in the freshman and sophomore ROTC courses is open to all MIT students. To be eligible for Army ROTC scholarships and/or enrollment in the junior- and senior-year ROTC courses, students must be citizens of the United States; physically and medically qualified in accordance with existing Army regulations; and enrolled at MIT, Harvard University, Tufts University, Wellesley College, Lesley University, Endicott College, Gordon College, Gordon-Conwell Theological Seminary, or Salem State University as full-time students.

Application Procedure
Students normally apply for the four-year program during their freshman year, but students may enroll in the course or apply for a campus-based scholarship each semester. Interested students can inquire about the Army ROTC program by visiting the Army ROTC office in Room W59-192, 617-253-4471, or by visiting http://web.mit.edu/armyrotc/.

Naval ROTC
The purpose of the Naval ROTC program is to provide instruction and training in naval science subjects which, when coupled with a bachelor’s degree, qualify selected students for commissions in the US Navy and US
Marine Corps. Upon graduation, commissionees serve in the unrestricted line of the Navy or Marine Corps. Unrestricted line officers will be expected to serve in the aviation, submarine, surface warfare communities, or the Marine Corps. Additionally, MIT commissionees are eligible to become Naval Reactors Engineers in Washington, DC.

The Naval ROTC unit at MIT offers two officer development programs: the Scholarship Program or the College Program. The Scholarship Program provides full tuition, all fees, uniforms, a semester book stipend, and a monthly stipend for two, three, or four years. Depending on which community is selected for service selection, the active duty obligation for the scholarship students is from four to eight years. Students in the College Program for two, three, or four years receive naval science books and all uniforms, in addition to a monthly stipend during the last two academic years if accepted for advanced standing by Naval Service Training Command. Students in this program must complete one summer cruise after their junior year and incur a three-year active duty obligation. Each year many of the top College Program students receive full-tuition scholarships for their remaining years in school. The monthly stipends are $250 for freshmen, $300 for sophomores, $350 for juniors, and $400 for seniors.

Harvard and Tufts students are eligible for both the Scholarship and College Programs.

Upon completion of the program and receipt of a baccalaureate degree, graduates are commissioned as Ensigns or Second Lieutenants in the Navy or Marine Corps. Newly commissioned officers report directly to active duty (or, in some cases, within one year of commissioning, generally within a few months). Upon completion of the active duty obligation, the officer may be released to inactive duty, but must serve in the individual ready reserve for a total of eight years from the date of original commissioning.

Program of Instruction
The Naval ROTC program of instruction encompasses the science of nautical matters and principles of leadership and management, all vital to being a naval officer. The program has three interacting and equally important aspects. The first aspect consists of the professional academic subjects taught by the Naval Science Department (one two-hour naval science subject is required each term), and the second aspect consists of the academic subjects taught by the Institute. In addition to recommended coursework, one year of calculus, physics, English, and one term of American military history or national security policy are required. The third aspect consists of the professional training gained from leadership laboratories (two hours a week throughout the school year), tours conducted to local naval facilities, cruises aboard active duty naval vessels, and practical navigation and piloting practice conducted aboard training craft.

Between academic years, midshipmen attend a month of summer training aboard active duty naval vessels and at shore bases throughout the world to become familiar with Navy and Marine Corps procedures.

Eligibility Requirements
To be eligible for the four-year Naval ROTC program, an entering student must be a United States citizen, at least 17 years of age, and physically qualified by the Department of Defense Medical Review Board.

Application Procedure
Further information can be obtained from the Commanding Officer, NROTC and Naval Administrative Unit, Room W59-110, at any US Navy Recruiting Station, or at http://navyrotc.mit.edu.

Admissions

Freshman Admissions
The information provided here contains a broad overview of Admissions policies and procedures. For specific information and application deadlines, visit the Undergraduate Admissions website at http://mitadmissions.org.

Secondary School Preparation
The majority of undergraduate men and women enter MIT as members of the freshman class directly following completion of secondary school studies. MIT expects that its applicants will have enrolled in a broad, rigorous program in high school. Applicants should be able to read with intelligence and sensitivity and to express ideas clearly in spoken and written form. In mathematics, emphasis should be on mastery of fundamental principles, operations, and definitions, and on preparation for the study of calculus. Work in the sciences should stress basic concepts and quantitative understanding, both in the classroom and in the laboratory. Ideal preparation for MIT includes English (four years), history and social studies (two or more years), mathematics (four years, including a strong preparation in algebra, plane geometry, trigonometry, and calculus), sciences (four years, preferably including general science, biology, chemistry, and physics), and a foreign language. However, interested students whose high school program does not match this curriculum in every detail are also invited to apply.

Application Procedures
Applicants are encouraged to visit the Admissions website at http://mitadmissions.org and register for a MyMIT account, through which prospective students can apply, track their application and financial aid forms, and arrange for overnight and day visits. The application will be available online beginning in the summer of the year prior to proposed entry. Early Action (available to citizens and permanent residents of the United States only) has a November 1 deadline. Regular Action candidates must complete the application process by January 1 of the year of intended entrance. Completed Early Action applications will be considered in mid-December. At that time the committee may offer admission, deny admission, or defer the decision to Regular Action. Deferred applications are reconsidered without prejudice in March. A student who seeks early consideration in this way is free to file applications at other colleges and, if offered admission at MIT, is not required to reply to the Institute before the candidates’ reply date in early May. There is an application fee for both Regular and Early Action which may be waived with the submission of a fee waiver request.

Additionally, MIT participates in the QuestBridge National College Match program. Interested applicants should consult http://www.questbridge.org/mit-app-requirements.
### Applicant Interviews
MIT highly recommends that applicants interview with a member of the MIT Educational Council. Council members are MIT graduates who have volunteered to interview for the Office of Admissions. Applicants will be referred via their MyMIT account to a member of the council near the applicant’s home. Details and interview deadlines can be found on the Admissions website, [http://www.mitadmissions.org/topics/apply/interviews_educational_counselors_ecs/index.shtml](http://www.mitadmissions.org/topics/apply/interviews_educational_counselors_ecs/index.shtml).

### Campus Tours and Information Sessions
Prospective applicants and their families are welcome to visit the Admissions Reception Center in Room 10-100, Monday through Friday between 9 am and 5 pm. Undergraduate admissions information sessions are offered year round each weekday (except holidays) at 10 am and 2 pm. Student-guided tours of the campus follow immediately after at 11 am and 3 pm. Visit [http://mitadmissions.org/](http://mitadmissions.org/) for the most up-to-date schedule and to register for an information session and campus tour.

### Deferred Admissions
Occasionally, students may wish to take one or two years off between secondary school and college. In such cases, it is recommended that the student follow normal admissions procedures, as if going directly on to college, and then request deferment. Deferrals are granted for many reasons, except full-time enrollment at another school.

### Advanced Placement
MIT has always encouraged students to move ahead academically according to their capabilities. There are four procedures by which students entering from secondary schools may receive credit and/or placement: the College Board Advanced Placement Program; A-levels, the International Baccalaureate, Cambridge Pre-U, and other international exams; college transcript; and Advanced Standing Examinations at MIT. Students are responsible for submitting exam scores or other materials in support of credit and placement requests. For detailed information, see websites for the Class of 2016 and Transfer Students.

Students who take college-level subjects offered in their schools in cooperation with the College Board Advanced Placement Program should take the appropriate examinations administered by the board each year and instruct the board to send the scores to MIT. Degree credit for some MIT subjects and, where appropriate, advanced placement, is given on the basis of a high achievement on the exams (in most cases a score of 5). A score of 5 on humanities, arts, and social sciences exams recognized by MIT grants 9 units of credit, applicable to the unrestricted elective requirements only, for each recognized exam. This credit does not reduce the General Institute Requirement of eight one-term subjects in the areas of Humanities, Arts, and Social Sciences.

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 seek MIT credit under the regular college transfer procedures. Decisions on transfer credit are made by MIT’s academic departments; they rarely approve transfer credit for online study or for dual-enrollment classes taught in high schools. The departments of Chemistry, Mathematics, and Physics review transfer credit requests during the summer before matriculation; all other transfer credit must be requested after the academic year begins. Advanced Standing Examinations for incoming students are given during Orientation. Incoming students will be notified before fall registration about credit earned from Advanced Placement and international exams; math, physics, and chemistry transfer credit; and Advanced Standing Examinations.

### Standardized Testing Requirements
Specific SAT, ACT, and TOEFL testing requirements are outlined in detail on the Admissions website, [http://www.mitadmissions.org/apply/freshman/tests/](http://www.mitadmissions.org/apply/freshman/tests/). The last acceptable testing date for Regular Action freshman admission to the Class of 2017 is the January 2013 testing date. If you take January tests, you must list MIT as a school to receive your scores or we will not receive them in time for our review. Note that the closing dates for registration are usually four to six weeks (five to seven weeks outside the United States) before the testing date. Students should request that the testing agency send all scores directly to MIT (code 3514 for the SAT and TOEFL; code 1858 for the ACT).

These examinations are offered throughout the world. The test dates, locations, and fees for the SAT Reasoning and SAT Subject Tests and TOEFL are outlined in an information bulletin that may be obtained online at [http://www.collegeboard.org/](http://www.collegeboard.org/), most guidance offices, or by writing directly to the College Board, 45 Columbus Avenue, New York, NY 10023. Information about the ACT may be obtained at [http://www.act.org/](http://www.act.org/) or by writing to ACT, 500 ACT Drive, P.O. Box 168, Iowa City, IA 52243.

### English Proficiency
Lectures, laboratory sessions, and written and oral examinations at MIT are conducted in English.

### College Transfer Admissions
Students who have completed a minimum of one year and a maximum of two and one-half years at the time of entry to MIT may be considered for transfer admission.

A student contemplating transfer to MIT should plan a program of studies to include as many as possible of the mathematics, physics, biology, chemistry, and humanities, arts, and social sciences subjects as are included in the typical first two years of MIT.

Specific testing requirements are outlined in detail on the Transfer Admissions website, [mitadmissions.org/apply/transfer/documents/](http://mitadmissions.org/apply/transfer/documents/).

Transfer applicants from foreign countries are admitted only for September entrance. Admitted and enrolling transfer students are required to complete at least three terms at MIT in order to earn a degree.

### Application Procedures
**Application Cycles**

For September entry, the application and all supporting documents are due by February 15. For domestic applicants seeking February entry, applications are due by November 15. (Citizens of foreign countries may apply for September entry only.) There is a nonreturnable application fee for transfer admission.

Applicants must submit the following documents:

- A certified transcript of the college record to date
- Three letters of recommendation from faculty instructors
- A secondary school transcript sent directly from the secondary school to the Admissions Office
- Standardized test reports

For transfer student financial aid information, see the section on Financial Aid.

**Advanced Credit**

Students admitted by transfer may receive credit for subjects of study completed elsewhere (with a grade of C or higher) that are substantially equivalent to corresponding Institute subjects.

**Special Student Admissions**

The Institute can accept a limited number of undergraduates who wish to undertake special studies and who are not degree candidates at MIT, but who have had at least one year of study at another college or university. Special Students enjoy most of the privileges of the regular student but are not eligible for research, campus housing, or financial assistance from MIT. Students wishing to apply for special student status should visit the Special Student website.

Special student status is granted for one term only, and a new application for this status is required for any successive terms. Admission as a special student does not carry any implication for other applications. It is a guest status only and not a means to an undergraduate degree at MIT. Applicants must present strong academic credentials. Admission is also a guest status only and not a means to an undergraduate degree at MIT. Students wishing to apply for special student status should visit the Special Student website.

More information, including application deadlines and fees, and the downloadable Special Student application can be found on the Special Student website, [http://web.mit.edu/admissions/graduate/special_students/index.html](http://web.mit.edu/admissions/graduate/special_students/index.html).

Deadlines for filing applications are August 1 for fall term, January 1 for spring term, and May 1 for summer term. Deadlines for international student applicants are June 1 for fall term, November 1 for spring term, and March 1 for summer term. International students living abroad are not permitted to apply for the summer term.

**Costs**

Undergraduate student costs for the academic year 2012–2013 at MIT will be about $57,010. This includes $42,050 for tuition and mandatory fees, plus an estimate for the costs of room and meals, books, supplies, and personal expenses. An allowance for travel is added to the student costs if the student lives in the United States. The allowance varies depending on the student’s home address. The cost of books and supplies, clothes, laundry, recreation, and other personal necessities vary widely, depending upon interests, tastes, and needs, but typically total about $2,772. There are many dining and housing options available at MIT and the range of student expenses for room and board is broad. Student Financial Services uses a standard allowance of $12,188 for room and meals. Actual costs for 2012–2013 may be more or less than the standard allowances based on individual costs.

The following are the basic tuition and fees at MIT for the academic year 2012–2013 (which are reviewed and likely to increase each year):

- Tuition: $41,770
- Student Activity Fee: $2,800
- MIT Student Extended Insurance Plan (optional): $1,980

Payment of the tuition fee entitles all regular and special students to many health care services at MIT Medical (Building E23) at no charge.

The MIT Student Extended Insurance Plan covers hospitalization due to accidents or illness. The insurance is required for all students, unless they can demonstrate that they have comparable coverage through another insurance program. Refer to the Medical Requirements section of this chapter for additional details or visit [http://medweb.mit.edu/](http://medweb.mit.edu/).

The tuition for all regular undergraduates in the fall and spring terms is $20,885 per term. Full tuition in either term of the current year covers the January Independent Activities Period (IAP). Tuition rates for the Summer Session are published each year in the Summer Session Catalog, available in April.

Regular undergraduate students who have permission to take only a few subjects are initially charged full tuition. They may then apply to have their tuition charged at the rate of $650 per unit with the approval of the faculty advisor. In such cases, there is a minimum fee of $3,900 for subjects and a minimum of $1,740 for the SB thesis. Registration for 32 or more units will be assessed the full tuition charge. Upon recommendation of a department, the Dean for Undergraduate Education, in the case of an undergraduate student, may set a special tuition rate in unusual circumstances. Financial aid will be adjusted based on enrollment costs. Some classes (including ROTC and classes taken on listener status) are not included in the determination of financial aid eligibility.

Special students are charged at the rate of $650 per unit taken either for credit or not for credit. This unit fee applies up to a maximum of $20,885 per term and is subject to the following minimum fees:
Members of the MIT community $3,900
(Includes special students who are full-time employees of the Institute or who are dependents of full-time employees or regular students.)
Other special students $5,850

Internship and cooperative programs offered by MIT provide industrial and research experience through a series of work assignments interwoven with regular study at the Institute. The tuition fee for these programs is the same as that for other regular undergraduate students:

- Electrical Science and Engineering, or Electrical Engineering and Computer Science, or Computer Science and Engineering, Course 6-A

Upon recommendation of the department, a special tuition rate for any cooperative program may be set in an unusual case. Light-load tuition adjustments are not normally available to students who are (or were) in cooperative and internship programs.

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

If the student receives financial aid through one of the Title IV federally based student financial aid programs, and aid is reduced as a consequence of the reduced tuition, the reduction in aid will be made in accordance with current federal regulations. Contact Student Financial Services for examples of refund calculations.

Miscellaneous Fees

Miscellaneous fees include the following:

- Application fee for undergraduate admission $75
- Fee for late submission of preregistration ($85 if very late) $50
- Fee for late filing of the degree application ($85 if very late—see Academic Calendar preceding the Overview section in Part 1) $50
- Fee for late initiation of the registration process or very late registration $100

Miscellaneous fees are nonrefundable unless levied in error.

Payment of Tuition and Other Charges

An individual who registers as a student at MIT agrees to pay all charges on his or her account when due, and acknowledges that the Institute may charge late payment fees, suspend registration, revoke Institute services, and withhold the degree if these charges are not paid.

Student Financial Services (SFS) gathers, bills, and collects student charges and provides a student account statement of that activity. These charges originate in the offices from which the student receives Institute services. SFS bills by posting a monthly student account electronic billing statement on MITPAY—a secure, paperless online billing and payment system. The statement is posted by the 10th of any month in which there’s a new charge or credit on the account. SFS sends courtesy email reminders to students each month to check the statement and pay any balance due.

The statement includes charges (e.g., tuition, fees, housing, and library fees), payments (financial aid, tuition awards), additional amounts due, and payment deadlines. Visit http://web.mit.edu/sfs/bills/index.html for more information on getting and paying the student account bill.

Payment in full or a satisfactory arrangement for payment is due prior to the beginning of each term (July 1, August 1, and January 1). New charges and credits that occur after the initial statement will appear on a subsequent statement. If a student anticipates that he or she may not be able to pay the entire account by the July, August, or January deadline, the MIT Payment Plan is available and should be considered.

The MIT Monthly Payment Plan is an installment arrangement administered by Tuition Management Systems (TMS) that allows students to pay their bills in monthly installments interest free. The terms and conditions of the monthly payment plan can be found at http://web.mit.edu/sfs/afford/monthly_payment_plan.

SFS also offers information on various loan programs as additional options, including federal programs. For more information visit http://web.mit.edu/sfs/loans/get_a_loan.html.

If a student fails to make satisfactory arrangements for payment and has amounts outstanding after a payment due date, that balance will be subject to late fees of 1.5 percent per month (18 percent annual percentage rate). Outstanding balances at the end of a term will result in a hold on the student’s registration or graduation. Student accounts unpaid after the student has left MIT for any reason may be reported to credit bureau agencies, sent to an outside collection agency, and assessed additional collection fees.

SFS staff members are available to answer questions and offer assistance in resolving billing matters related to student accounts, payment options, billing sponsors, educational loans, refund and cash advances. Visit SFS in the Student Services Center, Room 11-120, or http://web.mit.edu/sfs/.

Undergraduate students are subject to the Financial Hold policy adopted by the Committee on the Undergraduate Program (CUP) and the Committee on Academic Performance (CAP) in 1998. Students who have not paid their outstanding student account balance, made satisfactory arrangements with SFS to pay the balance, or completed a financial aid application by the end of the term will lose access to student services for
subsequent terms. Removal of services includes the right to register for the term, Athena access, MIT housing, dining, the MIT Card, and library access. Students who have not made efforts to resolve their financial problems will not be allowed to register or receive credit retroactively.

**Non-payment of Tuition and Other Charges**

If a student has an outstanding balance at the end of the term, including Independent Living Group charges, the student’s graduation or registration for the subsequent term is placed on hold.

Students who have unanticipated financial problems during a term should resolve them using the resources of SFS and Student Support Services (SS), as well as outside sources such as parents and relatives. The policy is designed to allow students sufficient time to resolve their financial difficulties. Students owing fall term balances have six months, from August to January, to clear their accounts before a hold on registration is imposed; students owing spring term balances have five months, from January through May. This should be sufficient time for students to deal with their financial issues.

To resolve financial holds, students should contact their counselor for customer service in the Student Services Center, Room 11-120.

**Policy on Undergraduate Financial Holds**

Undergraduates with unpaid balances will not be allowed to register for any subsequent term, receive credit retroactively, nor receive any student services, including but not limited to the libraries, dining system, computing resources, and Institute housing. To assure the timely payment of bills and equitable treatment of students, as well as to educate students about their rights and responsibilities in meeting their financial obligations to the Institute, the following procedures have been approved by the Committee on the Undergraduate Program and the Committee on Academic Performance.

Notifications to Undergraduates with Unpaid Balances

After the fifth week of the term, SFS will identify undergraduates who have unpaid balances on their student accounts for that term and who have not made satisfactory arrangements for payment of those balances. SFS will notify these students—both through the regular billing process and by email—informing them of the MIT policy regarding financial holds and registration holds for subsequent terms.

After the eleventh week of the term, SFS will identify undergraduate students who have unpaid balances on their student accounts for that term and who have not made satisfactory arrangements for payment of those balances. SFS will notify these students—both through the regular monthly billing process and by email—informing them of the Institute’s policy regarding financial holds.

Removal of Services

Undergraduate students who have not paid or negotiated satisfactory arrangements for payment of unpaid balances from the previous term may not register for subsequent terms, and therefore may not partake of Institute student services. When students have not made satisfactory payment arrangements by Registration Day of the subsequent term, SFS and other Institute offices may take the following actions:

- The right to live in MIT housing is suspended.
- The MIT Card is deactivated, and undergraduates are not authorized to use the services for which the card provides access. These services include but are not limited to the libraries, the dining system, computing resources, and Institute housing.
- Students are permitted to retain an mit.edu email address which will be forwarded to a specified outside email provider until the normal graduation date. All other computer services, including Athena access and use of MIT licensed software, will be suspended.
- Undergraduates will be excluded from the student payroll and UROP systems.
- Undergraduates will not be placed on class rosters and will be removed from class lists generated through the HASS-D lottery. They will not be allowed to participate in class projects. Work that is turned in for the class will not be graded or returned.
- Undergraduates will not have their financial aid applications reviewed for the upcoming academic year until their past due balance is cleared.

Undergraduates who do not settle their prior term balances or who have not made efforts to resolve their financial problems will not be allowed to register for the subsequent term or receive credit retroactively. Students who face loss of services should immediately contact their counselor for customer service in Room 11-120.

**FINANCIAL AID**

**Grants, Loans, and Employment**

MIT meets the full financial need of every undergraduate for all four years of his or her undergraduate career. Student Financial Services (SFS) awards grants and loans based on the financial need of the individual student, as determined by analysis of information provided on the Free Application for Federal Student Aid (FAFSA) and the CSS Profile. Copies of the most recent parental federal tax return(s) are required in support of aid applications.

SFS reviews applications and makes need-based awards to students from the most suitable Institute grant and loan resources. MIT is fortunate in having received gifts from many benefactors, alumni, and friends to help support the educational needs of MIT students.

Students choose term-time and/or loan eligibility to meet their self-help requirement, which is an amount (determined by family income and other factors) that students are expected to contribute themselves. Student loan funds allow the student to pay part of the costs of his or her education on long-term credit under favorable financial terms. However, MIT student loans are granted to meet systematically calculated financial need only. Undergraduate loans are provided from several government and private sources, including the Federal Perkins Loan Program and the Federal Direct Stafford Loan Program.

Specific jobs are not assigned; students are expected to arrange employment most suitable to their own talents and schedules. SFS Student Employment website, [http://web.mit.edu/sfs/jobs/](http://web.mit.edu/sfs/jobs/) maintains listings of positions for students seeking part-time jobs during the term or full-time summer jobs. On-campus employment is usually available in residence halls, offices, libraries, and laboratories. Listings for off-campus positions
are also available. Students’ earnings from part-time work depend on experience and, of course, their time availability.

SFS Student Employment participates in the Federal Community Service Program (part of the Federal Work-Study Program). Eligible students work in jobs that have a direct impact on the Cambridge and Boston communities or their hometowns over the summer. Wages are subsidized up to the student’s work-study eligibility. For more information, visit http://web.mit.edu/sfs/jobs/paid_community_service.html.

All students who are thinking of attending MIT are strongly urged to explore all areas of financial assistance, including government and private scholarship and loan programs. A number of states sponsor scholarship programs for residents, and information on eligibility may usually be obtained from secondary school guidance counselors. ROTC programs at MIT may also provide substantial scholarship support.

For more information on financing an MIT education, see the SFS website, http://web.mit.edu/sfs/.

Applications
Details on applying for financial aid are available at http://web.mit.edu/sfs/financial_aid/.

Entering Freshmen and Transfer Students
Students who wish to be considered for financial aid should complete the Free Application for Federal Student Aid (FAFSA) and the CSS Profile form. SFS Financial Aid also requires the parents’ most recent tax returns, W-2 forms, and all schedules. An application for admission is not prejudiced by an application for aid; the two decisions are entirely separate. Need criteria have no bearing on admissions, and admissions criteria have no part in determining qualifications for aid.

International Students
As with other undergraduates, MIT meets the full need of international undergraduate students who demonstrate financial need. International students who wish to be considered for financial aid should complete the International Student CSS PROFILE online and provide verification of parent income.

Students should also seek aid from sources other than MIT. International students should make all arrangements for their financial obligations to MIT for their entire stay in the United States before leaving their home country.

For complete instructions on applying for financial aid, including the documents required, visit http://web.mit.edu/sfs/financial_aid/prospective_freshmen_and_transfer.html.

Upperclass Students
Enrolled students receiving financial aid are required to reapply each year for continued assistance in the following year. Award applications must be submitted no later than April 15 of the year preceding the term in which aid is anticipated. Upperclass students must complete the Free Application for Federal Student Aid (FAFSA) and the CSS Profile. The application process also requires a copy of the most recent parental federal tax return(s), and all applicants are expected to apply for a state grant where applicable, as well as any renewable grants received in prior years.

A student’s eligibility for MIT undergraduate grant funds will end when the student receives an initial degree, or after the equivalent of eight attempted or completed terms, whichever occurs first. Eligibility for Federal Pell Grants may continue beyond the eighth term under some conditions, but ends with receipt of a bachelor’s degree.

Eligibility for undergraduate loans continues through all undergraduate programs. A student becomes eligible for the higher loan maximums that pertain to graduate students upon enrollment in a graduate program. Additional information is available at http://web.mit.edu/sfs/loans/.

Veterans’ Benefits
Students who are receiving veterans’ benefits need to verify their enrollment each year in order to be certified. For more information, visit http://web.mit.edu/sfs/scholarships/VA_benefits.html.

Medical Requirements

Medical Report
MIT requires that all incoming students submit a medical history, have a complete physical examination, and document immunity against certain infectious diseases. Medical Report forms need to be submitted before registering for classes. Specific deadlines for each term are listed on the form itself. More information and downloadable Medical Report forms may be found at http://medweb.mit.edu/howdoi/guides/undergraduate.medreq.

Registration will not be permitted for any student who has not complied with the Medical Report and/or immunization requirements stated above.

Health Insurance
All MIT students must have health insurance that meets the requirements for the Massachusetts Student Health Insurance Plan (SHIP). Students with J-1 visas under MIT sponsorship must have insurance that also meets US Department of State regulations for themselves and their spouses and children who accompany them. More information about Massachusetts health insurance requirements may be found at http://medweb.mit.edu/healthplans/student/waiver.html.

MIT Student Health Plan
The MIT Student Health Plan consists of two health plans, the MIT Student Medical Plan and the MIT Student Extended Insurance Plan.

The MIT Student Medical Plan covers a wide range of services provided at MIT Medical, including primary care, many medical specialties, urgent care seven days a week, mental health care, and other services (see Medical Services in Chapter 2). Registered MIT students paying tuition to MIT are automatically enrolled in the MIT Student Medical Plan as part of their tuition. Student partners and children of students may use MIT Medical on a fee-for-service basis for limited services, or by paying a Partner/Child MIT Student Medical Plan premium for comprehensive access. To enroll their families, students must complete the MIT Student Health Plan enrollment form annually during the fall enrollment period. Partners and children of students who purchase the MIT Student Medical Plan premium must also provide evidence that they are enrolled in a health
insurance plan or may purchase the MIT Student Extended Insurance Plan. If students wish to enroll their spouse (or spousal equivalent) or children, a new enrollment form must be submitted each academic year (September to August).

The MIT Student Extended Insurance Plan is designed to coordinate with the MIT Student Medical Plan and provides coverage for more extensive care, such as hospitalization, diagnostic tests, physical therapy, surgery, prescription medication, and obstetrical care. Since health insurance is mandatory under Massachusetts law, all regular students and special students (registered with 27 or more units), including students on a J-1 or F-1 visa, are automatically enrolled in the MIT Student Extended Insurance Plan. Prior to the beginning of each term, students may submit an online request to waive the Student Extended Insurance Plan if they already have coverage which meets the Massachusetts requirements for student health insurance. J-1 students under MIT visa sponsorship may waive the MIT Student Extended Insurance Plan only if their policies meet both the Massachusetts requirements and specified United States Information Agency (USIA) requirements. Massachusetts state law requires coverage through an insurance carrier based in the United States. New waiver forms must be filled out each academic year.

Special students taking two or more subjects, but registered at MIT with less than 27 units, are eligible to purchase the MIT Student Extended Insurance Plan, but are not enrolled automatically.

The deadline for submitting enrollment forms and waiver forms is September 15 for fall term, February 15 for spring term, and June 15 for summer term.

More information about the MIT Student Health Plans, including benefits, rates, and enrollment or waiver processes, may be found at http://medweb.mit.edu/healthplans/student/.

Please contact MIT Health Plans at stuplans@med.mit.edu with enrollment or waiver questions, or contact Claims and Member Service at mservices@med.mit.edu with any questions about benefits or claims.
What graduate degrees does MIT offer? Can graduate students take classes at other institutions? What are the dates for submitting admissions materials? How much will it all cost? For current and prospective graduate students, this section has the answers.
GRADUATE STUDY AT MIT

For more than a century, MIT graduate programs have provided ideal environments for advanced study by faculty and students working together to extend the boundaries of knowledge. Traditionally a leader in engineering and science graduate education, MIT has also attained national prominence for its doctoral programs in mathematics and the physical and life sciences. Top-ranked graduate programs in economics; political science; linguistics; science, technology, and society; architecture; media studies; urban studies; and management have broadened the spectrum of graduate education.

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

The broad scope and high quality of its graduate education have made MIT an international leader. More than a third of its graduate students come from foreign nations. Significant efforts have been made, with some success, to increase the numbers of minority and women students attending MIT’s graduate programs. This representation of students from diverse backgrounds contributes greatly to the richness of the MIT community and to the excellence of its graduate academic programs.

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

Extensive resources for graduate study have developed naturally at MIT from a long tradition of emphasis on contributions to new knowledge. The wealth and diversity of teaching and research resources are described in the departmental sections in Part 2.

Although most graduate students find their interests served by programs available within a single department, many elect to work in interdisciplinary fields (described in the sections on Interdisciplinary Graduate Programs and Interdisciplinary Research and Study in Part 3), which may reach into two or more departments and involve work in any of MIT’s laboratories and centers. Special committees provide guidance in certain areas such as biomedical engineering, economics and urban studies, environmental engineering, instrumentation, management of technology, medical engineering, medical physics, operations research, technology and policy, and transportation. In other fields, interdepartmental programs are administered by ad hoc committees approved for each student and appointed by the dean for graduate education.

MIT’s libraries are a major resource for graduate study. Comprehensive collections are available in fields where MIT concentrates its teaching and research efforts. Through participation in the Boston Library Consortium and the Ivy League Partnership, graduate students, faculty members, and research staff have access to collections outside the Institute.

Another resource for graduate study is cross-registration in programs with Harvard University and Wellesley College, and joint degree programs with the Woods Hole Oceanographic Institution. Limited study opportunities are also available at Boston University, Brandeis University, Tufts University, and the Graduate Consortium in Women’s Studies.

Graduate students are encouraged to use MIT’s extensive athletic facilities. Teams comprised of both undergraduate and graduate students participate in intercollegiate competitions and the intramural athletic program.

Graduate students also share in the cultural and social activities and recreational facilities at MIT. Concerts and dramatic performances are frequently given by Institute groups and professional performers. Leaders in many fields give on-campus lectures and seminars, which are open to all members of the Institute community. MIT students also take advantage of the numerous cultural and intellectual opportunities in the Boston area, including free admission to the Boston Museum of Fine Arts and the Museum of Science. A more detailed description of campus activities can be found in the section on Campus Life in Part 1.

Independent Activities Period
During the January Independent Activities Period (IAP), graduate students may pursue their own interests, including thesis research and preparation for qualifying exams. They also may lead or participate in special activities during this four-week period.

Graduate students should read the section on Independent Activities Period in the Undergraduate Education portion of this catalog for details concerning academic credit and grades, and special-student status.

Office of the Dean for Graduate Education
The Institute has a single faculty that is responsible for both undergraduate and graduate instruction. The administration of graduate education rests with the president; the provost; the chancellor; the dean and senior associate dean for graduate education; and the Committee on Graduate Programs, a standing committee of the Faculty.

Each department exercises a large measure of autonomy for its graduate programs, under general guidelines established for the Institute as a whole. Each department has a departmental committee on graduate students, including one or more graduate registration officers, to administer department and Institute graduate procedures.

More detailed information about the organization, rules, regulations, and procedures of graduate education is given in the online publication, Graduate Policies and Procedures, at http://odge.mit.edu/gpp/.

Career Development
Global Education and Career Development helps students to make informed decisions about career goals and to find opportunities related to their professional objectives. Graduate students are encouraged to begin their career by visiting the office during their first year to learn what career resources are available.

Further information may be obtained from Global Education and Career Development, Room 12-170, 617-253-4733, fax 617-253-8457, or visit http://gecd.mit.edu/. See also the GEC description under Undergraduate Education in Part 1.
GENERAL DEGREE REQUIREMENTS

Graduate students may pursue work leading to any of the following degrees: Doctor of Philosophy (PhD), Doctor of Science (ScD), Engineer’s degrees, Master of Science (SM), Master of Engineering (MEng), Master of Architecture (MArch), Master of Business Administration (MBA), Master in City Planning (MCP), and Master of Finance (MFin). Graduate programs are described in individual department statements in Part 2, and in the Interdisciplinary Graduate Programs section in Part 3.

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

A student who expects to come to MIT for an advanced degree after earning an undergraduate degree elsewhere should give careful attention to undergraduate prerequisites as outlined by each department or program elsewhere in this catalog. For more specific information, a student should consult the department or program in which he or she wishes to enroll.

MIT degrees are “residence” degrees in the sense that a major portion of the work must be done on campus in association with the faculty, other graduate students, and the Institute community. The amount of time required to attain any one degree varies.

Graduate Subjects

Graduate subjects at MIT are classified as one of two types: G-level and H-level. A G-level subject indicates a subject approved for graduate credit. An H-level subject is a higher-level graduate subject that is an approved subject for a graduate degree. All master’s programs require a minimum number of H-level units. (See Section 2.85 of Rules and Regulations of the Faculty.)

The credit classification for each subject should be based on whether a subject qualifies for high-level credit in one or more graduate degree programs. This determination is typically left to the department’s graduate program committee or council, as they are in the best position to assess this for their graduate programs.

Master’s Degree

Master of Science With and Without Specification

For the degree of Master of Science, the student must have satisfactorily completed a program of study of at least 66 units of G- or H-level subjects, of which at least 42 units must be H-level, and a thesis, approved by the department in which he or she is enrolled. If 34 units of H-level subjects and the thesis are in a single approved program, as determined by a departmental committee on graduate students, the degree will be recommended with specification in this program; otherwise, the degree will be recommended without specification. The same high standard of academic performance in a program approved by a departmental committee on graduate students is required for either degree.

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

The satisfactory completion of the master’s degree requires the student to be in residence as a full-time regular graduate student for a minimum of one regular academic term (not the summer session). Every degree candidate working on a thesis must register for thesis in all terms during which his or her thesis research or writing is actually in progress and during the term his or her name appears on the degree list.

Master of Architecture

The graduate degree Master of Architecture is awarded upon the satisfactory completion of a program of study of at least 312 units of G- or H-level subjects approved by the Department of Architecture, of which 96 units must be H-level subjects, and the completion of a thesis acceptable to the Department of Architecture. The program requires three and one-half academic years of residence to fulfill the requirements. Advanced entry may be possible for students who have majored in architecture design at a “4 plus 2” architecture school. These students may complete the program in as little as two and one-half years depending on their academic experience and accomplishments.

Master of Business Administration

To be awarded the degree of Master of Business Administration through the two-year MBA program, the student must satisfactorily complete the first-term core classes and at least 144 units of G- or H-level elective subjects, of which 42 units must be H-level. One of these elective classes must be from a list of approved leadership courses. The student must also complete the Sloan Innovation Period (SIP) requirement. A B (4.0/5.0) grade point average is required at the time of graduation. The candidate must also have been in residence for four consecutive regular academic terms.

To be awarded the MBA degree through the Sloan Fellows Program in Innovation and Global Leadership, the student must satisfactorily complete a program of study that includes a slate of core subjects, plus at least 48 units of G- or H-level subjects (of which 42 units must be H-level). A B (4.0/5.0) grade point average is required at the time of graduation.

Master in City Planning

To be awarded the degree of Master in City Planning, the student must satisfactorily complete a minimum of 126 units, of which at least 42 units must be H-level subjects. The student must also complete a thesis acceptable to the Department of Urban Studies and Planning, and have been in residence for a minimum of two regular academic terms.

Master of Engineering

To be awarded the graduate degree of Master of Engineering, the student must have satisfactorily completed a structured program of at least 90 units, consisting of 66 units of G- or H-level subjects, of which at least 42 units must be H-level, and a thesis approved by the department of the School of Engineering in which he or she is enrolled. The candidate must also have been in residence for a minimum of one regular term.
**Master of Finance**

To be awarded the Master of Finance degree, the student must satisfactorily complete a minimum of 66 units of graduate subjects (of which at least 42 units must be H-level) from within a program of study that includes a slate of required courses, restricted and general electives, and a seminar. The student must also complete the Sloan Innovation Period (SIP) requirement. A B (4.0/5.0) grade point average is required at the time of graduation. The candidate must also have been in residence as a graduate student for at least two consecutive regular academic terms. In most cases, a summer term is also required.

**Master of Science in Management Studies**

To be awarded the degree of Master of Science in Management Studies through the one-year Master of Science in Management Studies Program, the student must satisfactorily complete a program of study that includes 66 units of G- or H-level subjects acceptable to the Sloan School of Management (of which 42 units must be H-level) and a 24-unit thesis. If the student chooses the 12-unit thesis option, then 78 units of G- or H-level subjects acceptable to the Sloan School of Management (of which 42 units must be H-level) must be completed. A B (4.0/5.0) grade point average is required at the time of graduation. Candidates must be in residence for two consecutive regular academic terms.

**Simultaneous Registration for Two Master's Degrees**

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

To satisfy the minimum requirements for the program, the student must complete (in addition to thesis units) at least 132 units of G- or H-level subjects, of which 66 units are unique to each department. At least 42 of each group of 66 units must be H-level subjects. In those instances where, for a single regular master’s degree or program, a department or program has established unit requirements in excess of the foregoing minimums, the department or program requirements prevail. Such excess of units in one department may not be applied to the program in the other department.

A student pursuing a Master in City Planning in addition to a second master’s degree must have both programs approved in the usual way, but the subject units for the Master in City Planning can be lowered at the discretion of the Department of Urban Studies and Planning.

Individuals who wish to qualify for a Master of Science degree in Real Estate Development, in addition to a Master of Architecture or Master in City Planning degree, will be required to satisfy all the subject requirements of each program. Specifically, candidates for the Master of Architecture degree must take 164 subject units (of which 96 units must be H-level subjects), and Master in City Planning degree candidates must take 126 subject units (of which 42 units must be H-level subjects). Individuals who wish to qualify for the master’s degree in Real Estate Development must also take at least 66 subject units unique to this program, of which at least 42 units must be H-level subjects. Students may submit a single thesis provided it is acceptable to the graduate committees of each program.

It is expected that such dual degree candidates will be in residence at least one term longer than expected if enrolled in a single degree program.

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

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

In special cases, the standing committee of an approved interdisciplinary program may act in lieu of one of the two participating departments.

**Two theses.** Occasionally an individual, already admitted for graduate study, may wish to pursue simultaneously two distinct master’s programs, fulfilling the thesis requirement with a separate thesis for each degree program. In such cases, the usual unit requirements for each program apply separately. Registration for two degrees is contingent upon approval by the second department of a request for admission. Such a request can be initiated by a petition approved by both departments and approved by the dean for graduate education.

**Simultaneous Award of Bachelor’s and Master’s Degrees**

An undergraduate student of the Institute who is enrolled as a candidate for the bachelor’s degree may be admitted by a department as a candidate for the master’s degree. Students must register as graduate students for at least one regular academic term (not the summer session) to be recommended for the simultaneous award of the bachelor’s and master’s degrees. The thesis submitted for the master’s degree may also be accepted by the department in fulfillment of the undergraduate thesis requirement, if any. A student wishing to pursue this type of academic program must apply for graduate admission in the usual way.

**Engineer’s Degree**

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

The following engineer’s degrees are awarded:

- Civil Engineer (CE)
- Electrical Engineer (EE)
- Engineer in Aeronautics and Astronautics (EAA)
- Engineer in Computer Science (ECS)
- Environmental Engineer (EnvE)
- Materials Engineer (MatE)
- Mechanical Engineer (MechE)
- Naval Engineer (NavE)
- Nuclear Engineer (NuclE)
The requirement for such a degree is the satisfactory completion of a program of advanced study and research approved by the appropriate department or interdepartmental committee of the School of Engineering. The minimum program consists of at least 162 subject units (exclusive of thesis units) and the completion of an acceptable thesis. The candidate must also have been in residence for a minimum of two regular academic terms. Every degree candidate working on a thesis is expected to register for thesis in all periods during which the thesis research or writing is actually in progress and during the term his or her name appears on the degree list. A department may accept a master’s thesis of superior quality for the engineer’s degree only if the student intends to use that document to fulfill the requirements of a single master’s degree.

**Doctoral Degree**

Doctoral degrees are offered by various departments and programs within each of MIT’s five schools; see each school’s chapter in Part 2, Schools and Courses, for the lists of degrees. A list of the interdisciplinary graduate degrees offered at MIT, including those offered by the MIT-Harvard Division of Health Sciences and Technology and the Joint Program with Woods Hole Oceanographic Institution, is available in the section on Interdisciplinary Graduate Programs. MIT offers the degrees of Doctor of Science and Doctor of Philosophy interchangeably in the engineering and science departments (except biology and brain and cognitive sciences) and from the Whitaker College of Health Sciences and Technology. These degrees certify creditable completion of an approved program of advanced study in addition to a research dissertation of high quality based on original research.

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

The course of advanced study and research leading to the doctorate must be pursued under the direction of the departmental committee on graduate students for at least four academic terms. In some cases, the required period of residence may be reduced, but in no instance can it be reduced to less than two regular academic terms and one summer session.

A student is enrolled in a program of advanced study and research approved by the department. The thesis research is in this same area, but the program often includes subjects reaching into several departments. If the field requires substantial participation by two or more departments, an interdepartmental faculty committee, approved by the dean for graduate education, should be appointed to supervise the student’s program.

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

**Nonresident Doctoral Thesis Research Status**

Nonresident status is intended for doctoral students who have completed all requirements other than the thesis. These students have limited access to the facilities and academic life of the Institute and pay a substantially reduced tuition. They may receive payments from MIT for up to 5 percent of tuition for their first three nonresident terms; after that, they may not receive any graduate awards through MIT. Permission to become a nonresident doctoral candidate must be obtained from the dean for graduate education at least one month prior to Registration Day of the term during which the student wishes to register in this category. There is a $100 charge for late requests. Consult the Office of the Dean for Graduate Education or see Graduate Policies and Procedures (http://odge.mit.edu/gpp/degrees/thesis.html#7) for additional information on nonresident status.

**Minor Program**

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

**Language Proficiency**

There is no Institute language requirement; however, several departments require that a candidate be able to read or speak one or two foreign languages with intermediate competence. A student may satisfy the requirement in one of three ways: by fulfilling the requirement before entrance by passing one or more intermediate or advanced subjects with a grade of C or better; through examination by the Foreign Languages and Literatures Section; or by taking a two-term subject in a language or languages offered by the Foreign Languages and Literatures Section. Depending on student demand, the section offers a choice of two-term language subjects, stressing the ability to read or speak in Chinese, French, German, Japanese, or Spanish. For the purpose of the second alternative, the section gives written examinations in Chinese, French, German, Japanese, and Spanish twice a year at the end of each term. Examinations in other approved languages are arranged individually upon request.

**Harvard University**

A regular or special full-time graduate student at MIT may enroll to take subjects (exclusive of thesis) at Harvard (except Harvard Extension School and Harvard Summer School) without paying additional tuition, provided that this enrollment does not exceed one-half of the student’s total registration for the term. This cooperative arrangement is not applicable to the summer session.

Requests for cross-registration must be approved by the student’s MIT department of registration and should be confined to subjects that are not offered at MIT. Students will not be allowed to attend classes in which additional registrants put an undue load on the instructors. The procedures to be followed are available at http://web.mit.edu/registrar/reg/xreg/harvard.html. Grades earned in Harvard subjects appear on MIT transcripts as the closest equivalent MIT grade.

**Wellesley-MIT Exchange**

Graduate students are eligible to participate in the Wellesley-MIT Exchange Program. Wellesley courses are not considered graduate-level subjects, but may be accepted for graduate credit toward a student’s degree with the approval of the department. For details about the exchange, see the program description in the Undergraduate Education section of Part 1.
Boston University
An arrangement for cross-registration has been made between the MIT departments of Economics and Political Science and the African Studies Program of Boston University. Details of the procedures to be followed are similar to those for Harvard-MIT cross-registration.

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

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

Graduate Consortium in Women’s Studies at MIT
Founded in 1992, the Graduate Consortium in Women’s Studies (GCWS) is a pioneering effort by faculty at six degree-granting institutions in the Boston area and MIT to advance women’s studies scholarship through a series of ongoing team-taught interdisciplinary graduate seminars, curriculum development events, and conferences that feature graduate student work. Currently there are nine participating institutions, including Boston College, Boston University, Brandeis University, Harvard University, MIT, Northeastern University, Simmons College, Tufts University, and the University of Massachusetts Boston.

In keeping with the collaborative tradition of women’s studies, GCWS offers seminars to students matriculated in graduate programs at our member institutions. Students in any discipline at MIT may register for GCWS seminars and receive graduate credit. Graduate students receive priority, but MIT undergraduates may also apply.

Several seminars are offered per year; enrollment in each is limited. Students who are interested in enrolling in GCWS seminars must complete a GCWS course application online. Undergraduate students must first consult with the director of Women’s and Gender Studies at MIT. Admissions decisions are based on the student’s background and brief statement of interest. The list of seminars offered and the online application are available at http://web.mit.edu/gcws/.

In GCWS courses, faculty explicitly integrate gender analyses with issues of class, race, culture, ethnicity, and sexualities, and the practical and public-policy implications of feminist theory and scholarship are considered. Courses are designed not only to examine existing feminist scholarship, but to open paths to the creation of new knowledge. GCWS graduate courses also provide crucial intellectual support for students pursuing feminist work within the framework of traditional disciplines. For additional information, contact gcws@mit.edu.

ADMISSIONS

Regular Graduate Admissions
A regular graduate student is an individual who has been admitted to the Institute and who is registered for a program of advanced study and research leading to any of the post-baccalaureate degrees offered by MIT.

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

A student registered in a program of study leading to the simultaneous award of the bachelor’s degree and master’s degree must apply for graduate study and be registered as a graduate student for at least one academic term (not the summer session) of his or her program of study.

Some engineering departments require students seeking a doctoral degree to qualify first for a master’s degree.

Undergraduate Requirements for Advanced Degrees
In addition to preparation in the specific field of interest, most departments require significant work in mathematics and the physical sciences, but some require as little as a year of college-level work in these disciplines. Requirements of individual departments are given in Part 2 of this catalog. Students with minor deficiencies in preparation may be admitted for graduate study; however, deficiencies in prerequisite or general or professional subjects must be made up before the student can proceed with graduate work dependent on them.

Application Procedures
Students normally begin graduate study in September. However, in several departments, suitable programs can be arranged for students entering in June or February. Prospective applicants should check with individual departments about their dates for admission and matriculation. Application deadlines vary by department. Deadlines are noted in the graduate admissions application packet. Fees will not be returned to late applicants, but may be applied to an application considered in the next term. Candidates for admission who are also applicants for financial aid should observe the same deadlines.

All applicants are encouraged to apply online. The online and downloadable applications are available on the Graduate Admissions website, http://web.mit.edu/admissions/graduate. Sloan School of Management application forms are available on the Sloan website, http://mitsloan.mit.edu/.

Inquiries about specific application and testing requirements, deadlines, and notification of decision for admission should be addressed to the appropriate graduate department.
International Graduate Admissions

Graduate student applicants who are citizens of countries other than the United States must have received a bachelor’s degree or its equivalent from a college, university, or technical institute of acceptable standing. The academic record and all credentials must indicate the ability of the candidate to complete the approved program of graduate study and research. Applicants are evaluated by the academic departments. Admission is granted on a competitive basis. Competence in written and spoken English is expected.

Students whose native language is not English and whose schooling has not been predominantly in English may be required to submit scores from the International English Language Testing System (IELTS) or the Test of English as a Foreign Language (TOEFL). Please check the Graduate Application for the requirements of your department. Students wishing to take the IELTS or the TOEFL should do so no later than December 31.

Inquiries about specific testing requirements for admission should be addressed to the appropriate graduate department.

Special Graduate Student Admissions

A special graduate student is one whose intended program of study is essentially graduate in nature but who is not a candidate for an advanced degree. Normally, such a student will have received a bachelor’s degree. All applications are made through the Admissions Office. Applications for the specific subjects will be evaluated and approved by the Office of Admissions and the graduate committee of the appropriate department or departments. Admission is valid only for one term; a student must seek readmission each term to continue at the Institute. Those applying for special graduate student status for the first time must pay an application fee. A new fee is required after two sequential terms. To be allowed to continue as a special graduate student, satisfactory academic performance must be maintained. Admission as a special graduate student does not imply any commitment toward an individual’s admissibility to regular graduate student status. Students should visit the Special Student website, http://web.mit.edu/admissions/graduate/special_students/index.html, to download the Special Student application.

Deadlines for filing applications are August 1 for fall term, January 1 for spring term, and May 1 for summer term. Deadlines for international student applicants are June 1 for fall term, November 1 for spring term, and March 1 for summer term. International students living outside the United States are not permitted to apply for the summer term.

A student who is neither a United States citizen nor a United States Permanent Resident is considered an International Student. The form I-20 or DS 2019 will not be issued for subject registration of less than 36 units. Most subjects at MIT are either 9 or 12 units each. Detailed information about policies and procedures for international special students can be found at http://web.mit.edu/admissions/graduate/special_students/international_students.html. Detailed information and downloadable application can be found on the Special Student website, http://web.mit.edu/admissions/graduate/special_students/index.html.

Graduate Student Status for Research Staff Members

In view of their full-time responsibilities on assigned research and their corresponding salary scales, Institute research staff or employees of the Lincoln Laboratory or the Charles Stark Draper Laboratory may not be full-time regular graduate students, but may, under certain conditions, be granted the status of special graduate student. However, a research staff appointee or an employee of the Lincoln Laboratory or the Draper Laboratory who desires to work for an advanced degree must be admitted as a regular graduate student and must complete the residency and other requirements of the degree program to which the individual has been accepted. This individual may not continue to hold a research staff appointment, nor include any work completed while employed as part of the thesis for an advanced degree.

Any research staff appointee and any employee of the Lincoln Laboratory or the Draper Laboratory may, by written permission from the director of the division (or his or her designate), apply for admission as a special graduate student for enrollment in one subject only per term (but not thesis), either as a listener or for academic credit.

Acceptance for such enrollment will be granted if, in the opinion of the instructor, the individual is qualified to undertake the subject and if section size permits. For this type of enrollment, the student will be assigned to an appropriate registration officer and will pay, whether as a student or listener, the fee established at the special student rate.

Other Employment

A graduate student may not interrupt an academic program to accept employment on the academic, administrative, or research staff, or as an hourly employee at MIT, the Lincoln Laboratory, or the Draper Laboratory either during the academic year or the summer, without the approval of the department head and the appropriate academic dean, and unless the work as an employee is unrelated to the student's thesis research. A thesis release form indicating such approval must be submitted to the appropriate personnel officer to effect such employment. A graduate student may not include in his or her thesis any material based in whole or in part upon work done while holding an academic or research staff appointment.

COSTS

The basic tuition and fees at MIT for the academic year 2012–2013 (which are reviewed and likely to increase next year) are as follows:

- Tuition: $41,770
- Student Activity Fee: $280
- MIT Student Extended Insurance Plan (optional): $1,980

Payment of the tuition fee entitles all regular and special students to many health care services at MIT Medical (Building E23) at no charge.

The MIT Student Extended Insurance Plan covers hospitalization due to accidents or illness. The insurance is required for all students, unless they can demonstrate that they have comparable coverage through another insurance program. For further information, see the MIT Student Extended Insurance Plan in the section on Medical Requirements in this chapter, or visit http://web.mit.edu/medical/.

The tuition for all regular students, including graduate student staff, in the first and second terms is $20,885 per term, except for students
entering the Sloan Master’s Program, the Leaders for Global Operations Program, and the Supply Chain Management Master of Engineering in Logistics Program, for whom the tuition is $28,960 per term. Full tuition in either term of the current year covers the January Independent Activities Period. The minimum term tuition charge for registration for doctoral thesis upon readmission as a resident student is $31,325 if not registered during the preceding regular term.

The tuition for all regular graduate students, including fellows, trainees, and academic staff in the 2012 summer session was $13,920. Special tuition rates apply to other students in the summer session. These are published each year in the Summer Session Catalog, available in April.

Special students (except in the Sloan School of Management) are charged at the rate of $650 per unit whether taken for credit or not. This unit fee applies up to a maximum of $20,885 per term and is subject to the following minimum fees:

- Members of the MIT community: $3,900
  (Includes special students who are full-time employees of the Institute or who are dependents of full-time employees or regular students.)
- Other special students: $5,850

Any resident graduate student making progress toward a degree is expected to register and is considered a full-time student. If a graduate student requires only part of a term to complete the thesis, full tuition for the term is charged, and adjustments to tuition are made at a later date. If the student was registered for thesis as a resident student in the immediately preceding term, regular or summer, tuition for thesis will be adjusted after acceptance by the department of the completed document on the basis of a charge of $1,740 per week from the starting date of the term, with a minimum of $1,740 for the master’s or engineer’s degree and $3,480 for the doctoral degree. If the immediately preceding term was the summer term and if the graduate student was not registered for thesis in that summer term, but was registered for thesis in residence in the previous second term, the minimum tuition for thesis is $10,440.

A student who continues to hold a fellowship, traineeship, or graduate staff appointment for the remainder of the term after delivery of the thesis continues to be regarded as a full-time student and the tuition will not be adjusted. In unusual circumstances, the dean for graduate education may set special tuition rates for graduate students.

Students who are permitted to undertake nonresident thesis research must register as nonresident doctoral candidates and, in the first three semesters of registration as a nonresident, pay tuition equal to approximately 5 percent of the regular full tuition ($1,045 per term for 2012–2013). For the fourth and subsequent semesters of registration as a nonresident, tuition will equal approximately 15 percent of the regular full tuition ($3,130 per term for 2012–2013). Following completion of the nonresident period, the student must return to resident status for completion and presentation of the doctoral thesis. If the student requires only part of this first term back in residence to complete the thesis, the tuition will be adjusted subject to a minimum of $10,115. Please consult Graduate Policies and Procedures (http://web.mit.edu/edge/gpp/) for additional information on nonresident status.

Cooperative and practice-school programs offered by MIT provide industrial and research experience through a series of work assignments interwoven with regular study at the Institute. The tuition fees for these programs are the same as those for regular graduate students:

- Chemical Engineering Practice School, Course 10-A
- Electrical Engineering and Computer Science, Course 6-A

The tuition fee for special graduate students in the Sloan School of Management (except for employees of the Institute or their children) is $1,135 per unit of registration, with a minimum charge of $10,215. There is a maximum charge of $37,000 per term for full-time special graduate students enrolled in the program. Students interested in the Sloan Fellows Program for Innovation and Global Leadership should consult the Sloan School of Management with regard to fees.

A student withdrawing before the start of a term is not charged any tuition for that term and any tuition payments previously made for that term will be refunded. Students withdrawing during the fall or spring 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 must pay full tuition and fees at the beginning of the term. Any subsequent reduction in fees is based on the date that cancellation of a subject or withdrawal from the Institute is effected. At that time, any excess payments which the student has made will be refunded.

Graduate Living Costs
Living expenses for graduate students vary widely depending on such factors as marital status, availability of resources, interests, and tastes. Monthly living costs (housing, food, and personal expenses) are roughly $2,590 for a single graduate student. These cost estimates do not include tuition, books, or the Hospital and Accident Insurance Policy. Campus housing for graduate students is limited and less than half of the graduate student population can be accommodated in Institute housing. On-campus dining opportunities are available to graduate students.

Miscellaneous Fees
Miscellaneous fees include the following:

- Application for graduate admission: $75
- Application for Master’s Program in Sloan School of Management: $250
- Late submission of preregistration material ($85 if very late): $50
- Late initiation of registration process or very late registration, or late submission of application for nonresident doctoral status: $100
- Late filing of degree application ($85 if very late—see Academic Calendar): $50
- Late thesis title: $85
- Processing of Registration Holds for next term resulting from prior term obligations that are not cleared at least two weeks prior to Registration Day of that next term: $100
Completing an Incomplete by a Not Registered Candidate (per subject) $50
Library processing fees:
  Doctoral theses $115
  All other theses for advanced degrees $50

Processing Charges for Late Changes in Registration
A late change in registration, which requires a petition to the Office of the Dean for Graduate Education, is defined as adding a subject after the fifth week or dropping a subject during the last three weeks of a term. The processing charge for late changes is $50. There is an additional charge of $50 for a retroactive change after the end of the term.

The miscellaneous fees and processing charges listed above are non-refundable, unless levied in error.

Payment of Tuition and Other Charges
An individual who registers as a student at MIT agrees to pay all charges on his or her account when due, and acknowledges that the Institute may charge late charges (or finance charges for MIT Payment Plan accounts), suspend registration, revoke Institute services, and withhold the degree if these charges are not paid.

Student Financial Services (SFS) gathers, bills, and collects student charges and provides a student account statement of that activity. These charges originate in the offices from which the student receives Institute services. SFS bills by posting a monthly student account billing statement on MITPAY—a secure, paperless online billing and payment system. The statement is posted by the 10th of any month in which there’s a new charge or credit on the account. SFS sends courtesy email reminders to students each month to check the statement and pay any balance due. The statement includes charges (e.g., tuition, fees, housing, and library fees), payments (financial aid, tuition awards), additional amounts due, and payment deadlines. Visit http://web.mit.edu/sfs/bills/index.html for more information on getting and paying the student account bill.

Payment in full or a satisfactory arrangement for payment is due prior to the beginning of each term, (July 1, August 1, and January 1). New charges and credits that occur after the initial statement will appear on a subsequent statement. If a student anticipates that he or she may not be able to pay the entire account by the July, August, or January deadlines, the MIT Payment Plan is available and should be considered.

The MIT Monthly Payment Plan is an installment arrangement administered by Tuition Management Systems (TMS) that allows students to pay their bills in monthly installments interest free. The terms and conditions of the monthly payment plan can be found at http://web.mit.edu/sfs/afford/monthly_payment_plan.html.

SFS offers information on various loan programs as additional options, including federal and private programs. For more information, visit http://web.mit.edu/sfs/loans/get_a_loan.html.

If a student fails to make satisfactory arrangements for payment and has amounts outstanding after a payment due date, that balance will be subject to late fees of 1.5 percent per month (18 percent annual percentage rate). Outstanding balances at the end of a term will result in a hold on the student’s registration or graduation.

Student accounts unpaid after the student has left MIT for any reason may be reported to credit bureau agencies and/or sent to an outside collection agency and assessed additional fees on the outstanding balance.

Notifications to Graduate Students with Unpaid Balances
After the fifth week of the term, SFS will identify graduate students who have unpaid balances on their student accounts for the term and who have not made satisfactory arrangements for payment of those balances. SFS will notify these students—both through the regular billing process and by e-mail—informing them of the Institute’s policy regarding registration and graduation holds for subsequent terms.

After the eleventh week of the term, SFS will identify graduate students who have unpaid balances on their student accounts for the term and who have not made satisfactory arrangements for payment of those balances. SFS will notify these students—both through the regular monthly billing process and by email—informing them of the Institute’s policy regarding financial Holds.

Graduate students who do not settle their prior term balances or who have not made efforts to resolve their financial problems will not be allowed to register for the subsequent term or receive credit retroactively.

SFS staff members are available to answer questions and offer assistance in resolving billing matters related to student accounts, payment options, billing sponsors, educational loans, refunds, and cash advances. Visit SFS in the Student Services Center, Room 11-120, or http://web.mit.edu/sfs/.

FINANCIAL AID
MIT makes financial support available to graduate students from a variety of sources and in several different forms—fellowships, scholarships, traineeships, teaching and research assistantships, on-campus employment, and federal loans. Many forms of support are granted solely on the basis of merit, while others are granted on the basis of financial need or a combination of merit and need.

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

Information on fellowships and other financial aid resources is available from individual departments and the Office of the Dean for Graduate Education, Room 3-138. Information on loans is available from Student Financial Services (SFS), Room 11-320, or at http://web.mit.edu/sfs/loans/.

Fellowships, Traineeships, and Scholarships
At MIT, fellowships and traineeships differ from scholarships. A fellowship award to a graduate student covers full or partial tuition, and also provides a stipend to help defray living expenses. In the context of graduate study, a scholarship covers full or partial tuition only. Although most awards are made on the basis of academic merit, financial need is a factor in some instances. Recipients must be enrolled as regular resident students.

Insofar as fellowships, scholarships, and research and teaching assistantships provide for tuition payments, these funds are nontaxable.
When fellowships are less than tuition and an accompanying stipend exists, a portion of the stipend may be applied against the remaining tuition, and that portion excluded from taxable income (provided that the terms of the fellowship do not preclude this). Expenses for books, supplies, and equipment required for courses may also be excluded from taxable income. However, stipends accompanying teaching and research assistantships are taxable regardless of the amount of nontaxable tuition provided.

The Institute annually receives funds from individual and corporate donors for the support of fellowships and scholarships. In addition, government agencies and private foundations provide grants and fellowships—often directly to outstanding students for use at institutions of the student’s choice. But occasionally these funds are directed to MIT for Institute designation of recipients.

Applicants to MIT graduate programs who seek financial support from any of the fellowships, traineeships, or scholarships administered by MIT, including those granted by national agencies and foundations for award by the Institute, should inform their academic department. Currently enrolled graduate students who seek financial support should consult with the appropriate departmental office.

Applications for fellowship aid for the academic year, beginning in June or September, must be filed by January 15. Applications for fellowship aid filed after this date will be considered only if funds are available. Final action on applications is taken on the recommendation of departments at the end of March, after the announcement of awards to applicants by the national agencies and foundations under their national competitive programs. A student who wins such a fellowship may be eligible for only a supplementary award in accordance with MIT’s guidelines. For further information on these guidelines, see Graduate Policies and Procedures.

In accordance with a resolution of the US Council of Graduate Schools (endorsed by most 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 must register as a full-time regular graduate student for the period of the award. If a student withdraws from the Institute before tenure expires, the award must be relinquished, and the student will be required to refund any payment made in excess of tenure.

Teaching and Research Assistantships

MIT employs about 700 graduate students each year as part-time or full-time teaching assistants to assist the faculty in grading undergraduate quizzes, instructing in the classroom and laboratory, and conducting tutorials.

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

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

Appointments to teaching assistantships are made upon recommendation of the head of a department. A student who wishes to be considered for a teaching appointment should write to the department. Only full-time graduate students who are candidates for advanced degrees may be appointed. A Free Application for Federal Student Aid (FAFSA) is required for all teaching assistants who are US citizens or permanent residents.

Each year about 2,500 graduate students at MIT hold appointments as research assistants. The principal duty of a research assistant is to contribute to a program of departmental or interdepartmental research.

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

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

Teaching and research assistants receive stipends for the services that they provide; these stipends are taxable income that is subject to withholding tax. Teaching and research assistants also receive a nontaxable tuition scholarship. Students who are on visas should be aware of the US income tax regulations applicable to their visa status.

Students who receive financial support from other sources (fellowships, traineeships, etc.) may receive supplementary stipends as teaching or research assistants in accordance with Institute and departmental guidelines.

Loan Funds

A graduate student’s first recourse for loan assistance should be the Federal Direct Student Loan Program. To establish eligibility for this need-based loan, applicants must complete the Free Application for Federal Student Aid (FAFSA) online at http://www.fafsa.ed.gov/, and the MIT Graduate Loan Application, available on the web at http://web.mit.edu/sfs/forms_and_publications/. The maximum Federal Direct Unsubsidized Loan per year is $20,500. Application forms and details of the application procedure may be obtained from SFS Financial Aid in Room 11-320, or http://web.mit.edu/sfs/financial_aid/. Graduate students may be eligible for loans up to $8,000 from the Federal Perkins Loans program, based on information they provide on the FAFSA.

In determining need for the federal loan programs, MIT compares student resources available, including assets, using appropriate student budgets. Loan eligibility is determined within limits based on those budgets.

Students who need additional funding (beyond the $20,500 available via the Federal Direct Loan and the $8,000 available via the Federal Perkins Loan) may want to consider securing either a Federal PLUS Loan or another loan not based on financial need. The Federal PLUS Loan may be used to borrow the remainder of a student’s expenses, as may other programs offered by outside agencies.

International Students

Students who are not US citizens or who do not hold a permanent resident visa are not eligible for federal loans. International students must be prepared to meet their expenses without help from loans from the Institute. International Students may consider applying for private alternative loans. Most of these loans will require a US-based co-signer.
**Student Employment**

SFS Student Employment maintains listings of on-campus and off-campus job opportunities that are open to graduate students. Some positions are available directly through administrative offices on campus. Graduate students who hold full-time research or teaching assistantships or who receive full support on fellowships or traineeships usually are not eligible for such employment. The Office of the Dean for Graduate Education (http://web.mit.edu/edge/) should be consulted for approval before undertaking such employment. For additional information, visit SFS Student Employment in Room 11-320 or http://web.mit.edu/sfs/jobs/.

Graduate students who complete the Free Application for Federal Student Aid (FAFSA) and are eligible for Federal Work-Study may do paid community service. Wages are subsidized for students performing direct service at approved nonprofit agencies.

International students may only work on campus. Those considering off-campus employment must contact the International Students Office, Room 5-133, before accepting employment, or visit http://web.mit.edu/iso/.

**Graduate Residents**

Regular resident graduate students who have completed at least one graduate year at MIT or new students who have been MIT undergraduates may apply to Student Life Programs (http://web.mit.edu/slp/), Room W20-549, for positions as graduate resident tutors. Such positions provide room and board but no stipend.

**Veterans’ Benefits**

Students who are receiving veterans’ benefits need to verify their enrollment each year in order to be certified. Please send an email to VA@mit.edu for further information. Students may also wait until registration information appears online, typically the second week of the term. VA housing benefits stop when a student is not registered.

**MEDICAL REQUIREMENTS**

**Medical Report**

MIT requires that all incoming students submit a medical history, have a complete physical examination, and document immunity against certain infectious diseases. Medical Report forms need to be submitted before registering for classes. Specific deadlines for each term are listed on the form itself. More information and downloadable Medical Report forms may be found at http://medweb.mit.edu/howdoi/guides/undergraduate.html#medreq.

Registration will not be permitted for any student who has not complied with the Medical Report and/or immunization requirements stated above.

**Health Insurance**

All MIT students must have health insurance that meets the requirements for the Massachusetts Student Health Insurance Plan (SHIP). Students with J-1 visas under MIT sponsorship must have insurance that also meets US Department of State regulations for themselves and their spouses and children who accompany them. More information about Massachusetts health insurance requirements may be found at http://medweb.mit.edu/healthplans/student/waiver.html.

**MIT Student Health Plan**

The MIT Student Health Plan consists of two health plans, the MIT Student Medical Plan and the MIT Student Extended Insurance Plan.

The MIT Student Medical Plan covers a wide range of services provided at MIT Medical, including primary care, many medical specialties, urgent care seven days a week, mental health care, and other services (see Medical Services in Chapter 2). Registered MIT students paying tuition to MIT are automatically enrolled in the MIT Student Medical Plan as part of their tuition. Student partners and children of students may use MIT Medical on a fee-for-service basis for limited services, or by paying a Partner/Child MIT Student Medical Plan premium for comprehensive access. To enroll their families, students must complete the MIT Student Health Plan enrollment form annually during the fall enrollment period. Partners and children of students who purchase the MIT Student Medical Plan premium must also provide evidence that they are enrolled in a health insurance plan or may purchase the MIT Student Extended Insurance Plan. If students wish to enroll their spouse (or spousal equivalent) or children, a new enrollment form must be submitted each academic year (September to August).

The MIT Student Extended Insurance Plan is designed to coordinate with the MIT Student Medical Plan and provides coverage for more extensive care, such as hospitalization, diagnostic tests, physical therapy, surgery, prescription medication, and obstetrical care. Since health insurance is mandatory under Massachusetts law, all regular students and special students (registered with 27 or more units), including students on a J-1 or F-1 visa, are automatically enrolled in the MIT Student Extended Insurance Plan. Prior to the beginning of each term, students may submit an online request to waive the Student Extended Insurance Plan if they already have coverage which meets the Massachusetts requirements for student health insurance. J-1 students under MIT visa sponsorship may waive the MIT Student Extended Insurance Plan only if their policies meet both the Massachusetts requirements and specified United States Information Agency (USIA) requirements. Massachusetts state law requires coverage through an insurance carrier based in the United States. New waiver forms must be filled out each academic year.

Special students taking two or more subjects, but registered at MIT with less than 27 units, are eligible to purchase the MIT Student Extended Insurance Plan, but are not enrolled automatically.

The deadline for submitting enrollment forms and waiver forms is September 15 for fall term, February 15 for spring term, and June 15 for summer term.

More information about the MIT Student Health Plans, including benefits, rates, and enrollment or waiver processes, may be found at http://medweb.mit.edu/healthplans/student/.

Please contact MIT Health Plans at stuplans@med.mit.edu with enrollment or waiver questions, or contact Claims and Member Service at mservices@med.mit.edu with any questions about benefits or claims.
What is MIT's policy on grading? On plagiarism? On harassment? Does MIT disclose information about students to persons outside the Institute? This section contains the essential rules and regulations that govern day-to-day operations at MIT.

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ACADEMIC PROCEDURES

Registration
Information on preregistration and registration procedures is available at http://web.mit.edu/registrar/reg/index.html.

Retaining Student Status
A person becomes an MIT student at the start of the term for which he or she is admitted or readmitted. Regular student status is retained until graduation, unless the student withdraws or is disqualified.

For the fall and spring terms, undergraduate and graduate students must complete the three steps listed below in order to continue student status during that term:

- Preregistration must be completed according to instructions issued by the Registrar’s Office.
- All Institute and Fraternity, Sorority, and Independent Living Group (FSILG) charges must be paid when due, or satisfactory alternative arrangements must be made with Student Financial Services or the FSILG.
- Registration must be approved by the student’s advisor or registration officer and submitted by the student to the Registrar’s Office by the published deadline.

Students who do not complete these steps by the published deadlines are subject to fines. Failure to pay charges and complete registration by the end of the second week of the term will result in the loss of student status.

International students are required by immigration regulations to be registered full-time when school is in session in order to maintain legal status in the US. Students should check with the International Students Office (http://web.mit.edu/iso/) for details.

Undergraduate and graduate students registered in the spring term who do not graduate or withdraw from MIT retain their student status through the following summer, whether or not they register for the summer session; they cease being students if they do not register in the fall (although the rules for student status with regard to loan repayment are somewhat different). Graduate students making progress toward a degree during the summer must register for the summer session in accordance with Office of the Dean for Graduate Education regulations.

Students do not have to register for the Independent Activities Period to retain student status between fall and spring terms.

If a student has begun the registration process but wishes to withdraw, he or she must notify Student Support Services if an undergraduate; his or her registration officer if a graduate student; and, in addition, the International Students Office if an international student.

A person wishing to be reinstated as an undergraduate must apply for readmission through Student Support Services. No application for readmission to the undergraduate program will be considered from any applicant who has received a bachelor’s degree or the equivalent from another institution. A person wishing to be reinstated as a graduate student must apply for readmission through the Admissions Office and the department. International students also need to be cleared by the International Students Office.

People on campus who are not registered during a term are not considered students and have no student privileges.

Prerequisites
Prerequisites are used to indicate the sequence in which subjects are to be taken and the base of knowledge on which a particular subject will build. Before taking a subject, a student should complete any prerequisite(s) listed in the online MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi, for that subject. (Corequisites, which are listed in italics, are to be taken concurrently.)

Once prerequisites and corequisites are included in a subject listing, it is the responsibility of the instructor to ensure that the subject is taught at the appropriate level. At the first class, instructors should reiterate the prerequisites and corequisites, and describe acceptable substitutions.

Students who do not have the stated prerequisites should obtain the permission of the instructor. Instructors may request that the Registrar’s Office identify students without prerequisites, and in some cases, screen them from the subjects.

If the instructor allows a student to waive or make a substitution for a prerequisite, it is then the student's responsibility to master any missing background material in a timely fashion so that the content of the subject does not change for other students in the subject.

The instructor may determine that a student does not have the required preparation and knowledge to take a subject and may, with the help of the Registrar’s Office, exclude the student from the subject.

Some departments require students with a D-level performance in certain prerequisite subjects within the departmental program to do additional work or to retake the prerequisite before proceeding with the follow-on subject.

Credit Hours and Designations for Subjects
The credit hours (units) for each subject indicate the total number of hours spent each week in class and laboratory, plus the estimated time that the average student spends each week in outside preparation, for one regular term. Each subject is listed in the online MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi, with three credit numbers, showing in sequence the units allotted to class time (lecture and/or recitation); laboratory, design, or fieldwork; and preparation. Each unit represents about 14 hours of work per term. The total unit credit for a subject is obtained by adding together all the units shown. Additional information regarding subject designations may be found in the Explanatory Notes that introduce the online MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.

Advanced Standing Examinations for Undergraduates
Advanced standing examinations are given in August/September, December, January/February, and May. These examinations may be taken only by students who have never been registered for or attended class at MIT in the subject concerned. Special students are not eligible to take advanced standing examinations.

Except for entering freshmen and transfer students, who may take advanced standing examinations offered during orientation, students must
petition to take an advanced standing examination. The petition must be approved by the instructor in charge of the subject and the student’s advisor, and then submitted to the Schedules Office, Room 5-111, at least three weeks before the first day of the examination period.

Students interested in taking higher-level examinations should check in advance what preparation is required. The instructor may require evidence of competence in addition to the examination if the subject normally involves measures of student performance that are qualitatively different from the examination.

If a student fails an advanced standing examination, he or she may not retake the examination, but may register for the same subject in any subsequent term.

For more information, see the advanced standing examination procedures at http://web.mit.edu/registrar/ase-exams.

Term Regulations and Examination Policies
These term regulations and examination policies, available at http://web.mit.edu/faculty/teaching/termregs.html, derive from Rules and Regulations of the Faculty, available at http://web.mit.edu/faculty/governance/rules/. They apply to academic exercises during the fall and spring terms. Questions of interpretation and requests for exceptions to regulations should be referred to the Chair of the Faculty.

All Subjects
Class Times. Exercises should, in general, be held between 9 am and 5 pm, Monday through Friday. Exercises begin five minutes after and end five minutes before the scheduled hour or half-hour.

Beginning of Term. Early in the term, the faculty member should inform students of expectations regarding permissible academic conduct. Particular attention should be given to such questions as the extent of collaboration permitted or encouraged, and the use of prior years’ materials in completing problem sets, lab reports, and other assignments.

Scheduling Final Examinations. Final examinations are held during the five-day final examination period at the end of each term, and are scheduled through the Schedules Office. Final examinations are scheduled in either the morning (9 am to noon) or afternoon (1:30 pm to 4:30 pm) on examination days. A final examination must be scheduled to last at least one hour and not more than three hours. Final examinations may not be cancelled once they are announced, and, after the final examination schedule is published, the time of the final examination may not be changed. Instructors may not administer a take-home examination as a final examination, except as permitted with respect to ex camera examinations.

Students are responsible for attending the final examinations in subjects for which they are registered. The schedule of final examinations is published by the end of the third week of the term. The Schedules Office contacts students who have conflicts between scheduled final examinations to notify them of the conflict examination schedule, which is announced the day after Drop Date. The Schedules Office also provides instructors with the conflict examination schedule immediately after Drop Date.

After the Last Scheduled Class. No required classes, examinations, oral presentations, exercises, or assignments of any kind may be scheduled after the last regular scheduled class in a subject except for final exams scheduled through the Schedules Office. (The architecture design reviews that occur during finals week are considered to be equivalent to final examinations and are scheduled by the Department of Architecture.)

Formal review must be held during regular class periods. However, instructors may schedule optional reviews or sessions at which the instructing staff is available to answer questions for students who choose to attend after the last day of classes. No new material may be introduced during optional events.

An instructor may give an extension to an individual student for an assignment, but blanket extensions should not be given to the entire class.

Excused Absences from Final Examinations. A student may be excused from a scheduled final examination for reasons of illness or significant personal problems. To seek an excused absence in these situations, an undergraduate student should contact a dean in Student Support Services and a graduate student should contact the dean for graduate education; faculty members with questions about this process should contact the appropriate office. See definition of “O” and “OX” under Grades.

In addition, the faculty member in charge of a subject may excuse a student from a final examination for reasons such as a conflict with another examination or a religious holiday. In these cases, a mutually satisfactory agreement must be reached between the student and the faculty member, the agreement must be ratified in advance of the examination by the head of the department in which the subject is offered, and the faculty member must be prepared to submit a grade based on other evidence.

Faculty members are not required to provide make-up examinations to accommodate an individual student’s personal plans at the end of term.

Undergraduate Subjects
Class Times. For undergraduate subjects, during the instructional period of the fall and spring terms, there should be no required academic exercises between 5 pm and 7 pm, Monday through Thursday, and between 5 pm Friday and 8 am Monday.

Beginning of Term. By the end of the first week of classes, the faculty member must provide:

- A clear and complete description of the required work including the number and kinds of assignments
- The approximate schedule of tests and due dates for major projects
- Whether or not there will be a final examination
- The grading criteria and procedures to be used

By the end of the third week, the faculty member must provide the precise schedule of tests and major assignments.

Tests and Academic Exercises Outside Scheduled Class Times. Tests, required reviews, and other academic exercises held outside scheduled class times should not be held on Monday nights.

In addition, tests should:

- Not exceed two hours in length
- Be scheduled through the Schedules Office
- Begin no earlier than 7:30 pm when held in the evening
A student who is unable to take the test owing to a conflict with a scheduled academic exercise or extracurricular activity must be allowed to do so at another time.

When a test is held outside scheduled class time, during that calendar week:

- A regularly scheduled class hour (lecture or recitation) should be cancelled, or
- No assignment should fall due

**Ex Camera Finals.** In some undergraduate subjects, final examinations may be *ex camera* (out-of-room) examinations. *Ex camera* examinations are a different mode of testing that gives students access to computers and libraries and evaluates their abilities to select resources and answer questions of an integrative nature. *Ex camera* final examinations are not intended as a way to increase the amount of material covered.

A faculty member must obtain the permission of the Chair of the Faculty to hold an *ex camera* final examination and permission will be granted for no more than five years. The *ex camera* examination must:

- Be scheduled through the Schedules Office
- Be offered over the course of a single afternoon-starting at 1:30 pm and ending no later than 7:30 pm
- Permit students unrestricted use of resources

**End-of-Term Tests and Assignments.** In all undergraduate subjects, there shall be no tests after the Last Test Date, which is defined as the Friday preceding the start of the Reading Period. Unit tests may be scheduled during the final examination period.

For each subject in which there is testing during the final examination period, no assignment may fall due after the Last Test Date.

For each subject in which there is no testing during the final examination period, at most one assignment may fall due between the Last Test Date and the end of the last scheduled class period in the subject that is not a final examination. Whether the assignment derives from the final examination or the regular class period, no assignment may fall due after the Last Test Date.

In the event the Institute is closed because of snow or other emergency (see below), tests and academic exercises outside scheduled class times may be given, or one assignment, term paper, or oral presentation may fall due between the Last Test Date and the end of the last regularly scheduled class in the subject.

If an in-class test is given, its length is limited to one normal class period (or to one and one-half hours, whichever is shorter).

Students must not be required to attend additional lecture or recitation hours beyond the assigned units to accommodate oral presentations.

**Policy for Emergency Closing during Final Exams or on Registration Day**

Every effort must be made to give final exams as scheduled during the final examination period. Because students have included the final exam in their planning for the subject, faculty members may not choose to cancel exams; they must give the exam as scheduled, or as rescheduled in the event the Institute is closed because of snow or other emergency (see below).

- In case of inclement weather during exams, getting to MIT may be difficult for individuals involved with proctoring an exam. Thus, it is the responsibility of the department and the faculty member in charge to provide in advance for alternate staff who are physically at MIT and who have access to the written exam questions. Exam proctors will accommodate late student arrivals to the extent possible.
- In case of emergency closing or delayed opening during exams, students, faculty, and staff can call 617-258-8378 (617-258-TEST) or go to [http://finals.mit.edu/](http://finals.mit.edu/) to get up-to-date information during exam week. Exam information is also available from the “snow” link that is provided on the MIT home page ([http://web.mit.edu/](http://web.mit.edu/)) during emergencies. In the event of an emergency closing or delayed opening, callers receive specific instructions regarding rescheduled exam times and locations.
- If the Institute is closed, the exams scheduled during that period are postponed to the next available “contingency” exam periods, usually evenings 6-9 pm through the last day of the exam period, and either the second day of IAP (fall exams) or the day following the exam period (spring exams). If MIT has a delayed opening, for example, 10 am, then the starting time for exams is delayed. Details are given on the telephone line 617-258-TEST. A detailed schedule of postponed exams is available at [http://finals.mit.edu/](http://finals.mit.edu/).
- Students who miss exams given at the rescheduled times will be excused; faculty should submit the interim grade O, to which an “X” will be added routinely. These students will take a postponed final exam given near the beginning of the next regular term.
If the Institute is closed during part or all of Registration Day, students, faculty, and staff can call 617-258-8378 or go to http://web.mit.edu/registrar/calendar/religious.html to get up-to-date information regarding rescheduled registration activities.

Student Absence for Religious Observances
Massachusetts state law regarding student absence due to religious beliefs has been adopted by the Institute as follows:
Any student who is unable to attend classes or participate in any examination, study, or work requirement on a particular day because of his or her religious beliefs is excused from any such activity. The student will be given the opportunity to make up the work that was missed, provided that the makeup work does not create an unreasonable burden upon MIT.
The Institute will not levy fees or charges of any kind when allowing the student to make up missed work. In addition, no adverse or prejudicial effects will result because students have made use of these provisions.
For more information, visit http://web.mit.edu/registrar/calendar/religious.html.

Academic Performance and Grades
Undergraduate Academic Standards
The Committee on Academic Performance (CAP) ensures that the minimum academic standards proposed by the individual departments for undergraduate students are consistent throughout the Institute and conform to the rules and regulations approved by the faculty. In view of the individual nature of student academic performance, the CAP does not establish rigid standards of academic performance to be used throughout the Institute. The Institute generally expects undergraduate students to complete the requirements for a single SB degree in four years; the usual load of subjects is approximately 45–54 units of credit per term. Normally, however, the CAP accepts a minimum academic record of at least 36 units of credit with a term rating above 3.0 (on a 5.0 scale) at the end of any regular term, unless the Committee has specifically notified an individual student that a higher level of performance is required. (The latter would only occur as a result of previously poor performance.)
When these criteria are not met, the CAP considers each student’s academic performance on an individual basis. Consideration is given not only to the grades received in the various subjects for which the student is registered, but also to the total number of subject units, the nature of the subjects themselves, progress toward the degree, and those factors in the student’s own personal situation that may have affected his or her academic performance in a given term. The CAP website, http://web.mit.edu/acadinfo/cap/, gives more detailed information concerning end-of-term review procedures. For further information, contact CAP’s staff associate, Room 7-104, 617-253-4164.
Per the Code of Federal Regulations (Title 34, Volume 3, Sec. 668.34) regarding satisfactory progress, a regular undergraduate student is eligible to receive Title IV, HEA program assistance if the student is enrolled at least half time per term and maintains satisfactory progress in his or her course of study. A grade point average of at least a C (3.0 on MIT’s 5.0 scale) or academic standing consistent with MIT’s requirement for graduation (not to exceed 150% of the published length of the program) is considered satisfactory progress for an undergraduate student. All undergraduates whose performance falls below this standard will be considered, for Title IV purposes, to be under CAP review during the subsequent term. A student under CAP review will be considered to be making satisfactory progress unless the CAP withdraws permission for the student to continue.

Graduate Academic Standards
It is the responsibility of the Graduate Academic Performance Group (GAPG) to monitor minimum academic standards for graduate students and special students in accordance with the rules and regulations of the faculty. Chaired by the dean for graduate education, the GAPG reviews the academic records of all graduate students at the end of each term (including the summer session), giving particular attention to students with cumulative ratings below 3.5 to 4.0. Consideration is given to low grades and factors affecting a student’s ability to meet the requirements for the degree program in which he or she is enrolled.
Recommendations for action by the GAPG are made by departmental graduate committees. Unless extenuating circumstances are found, students who are not making satisfactory progress towards a degree may be denied permission to continue or may be warned that without substantial improvement the following term, they may be refused further registration. In addition, departmental graduate committees may recommend to the GAPG that a student be allowed to register only for a less advanced degree.
In order to receive federal financial aid under Title IV purposes, a graduate student is considered to be making satisfactory progress as long as his or her cumulative grade point average exceeds 4.0, and if the number of terms of enrollment does not exceed five for a master’s candidate or 13 for a PhD or ScD candidate. Graduate students whose performance falls below this standard will be considered, for Title IV purposes, to be under GAPG review during the subsequent term. A student under review will be considered to be making satisfactory progress if the GAPG does not withdraw permission for the student to continue.
The GAPG operates with the authority of the Committee on Graduate Programs (CGP). More detailed information concerning procedures followed by this standing faculty committee may be found in the online publication, Graduate Policies and Procedures, at http://odge.mit.edu/gpp/. It is also important for students to be informed about individual department requirements and expectations concerning academic performance.

Grades
In determining a student’s grade, consideration is given for elegance of presentation, creativity, imagination, and originality where these may appropriately be called for. Grades at MIT are not rigidly related to any numerical scores or distribution function, that is, grades are not awarded solely according to predetermined percentages. As can be seen from the following grade descriptions, a student’s grade in a subject is related more directly to the student’s mastery of the material than to the relative performance of his or her peers.

Passing Grades. Undergraduate and graduate students who satisfactorily complete the work of a subject by the end of the term receive one of the following grades:
A Exceptionally good performance demonstrating a superior understanding of the subject matter, a foundation of extensive knowledge, and a skillful use of concepts and/or materials.

B Good performance demonstrating capacity to use the appropriate concepts, a good understanding of the subject matter, and an ability to handle the problems and materials encountered in the subject.

C Adequate performance demonstrating an adequate understanding of the subject matter, an ability to handle relatively simple problems, and adequate preparation for moving on to more advanced work in the field.

Note that the MIT internal grading system includes plus (+) and minus (-) modifiers for use with the letter grades A, B, and C for all academic subjects (except advanced standing exams). These modifiers appear only on internal grade reports. They do not appear on transcripts and are not used in calculating term or cumulative grade-point averages. The MIT grading system for external purposes does not include modifiers.

D Minimally acceptable performance demonstrating at least partial familiarity with the subject matter and some capacity to deal with relatively simple problems, but also demonstrating deficiencies serious enough to make it inadvisable to proceed further in the field without additional work. Some departments require students with D-level performance in certain prerequisite subjects within the departmental program to do additional work, or to retake the prerequisite, before proceeding with the follow-on subject.

P When use of the passing grade P is authorized, it reflects performance at the level A, B, or C (A+ to C- with modifiers used within MIT), with the student graded on a P/D/F basis.

Non-Passing Grades. The grades and notations used for subjects not passed or not completed by the end of the term are as follows.

DN Signifies a D grade on Freshman Pass/No Record and ABC/No Record.
F Failed. This grade also signifies that the student must repeat the subject to receive credit.
FN Signifies an F grade on Freshman Pass/No Record and ABC/No Record.
O Absent. This grade indicates that the student was progressing satisfactorily during the term but was absent from the final examination, did not turn in the final paper or project, and/or was absent during the last two weeks of the term. Like an F grade, an O grade carries no credit for the subject, but the O grade can be converted to a grade of OX. Unsatisfactory performance because of absence throughout the term should be recorded as F.
OX Absence satisfactorily explained to and excused by the dean for undergraduate education in the case of an undergraduate student or by the dean for graduate education in the case of a graduate student. The faculty member in charge of the subject will be notified when an O is changed to an OX. An OX carries no credit for the subject. However, the faculty member in charge must provide the student the opportunity to receive a credit-carrying grade. This may be done with or without the instructor requiring a make-up final examination or other additional evaluation procedure.

I Incomplete. The grade I indicates that a minor part of the subject requirements has not been fulfilled and that a passing grade is to be expected when the work is completed. The grade I for the term remains permanently on the student's record even when the subject is completed. The work should normally be completed before Add Date of the succeeding term of the regular academic year; however, the faculty member in charge, in negotiation with the student, has the right to set an earlier or later date for pedagogical reasons or extenuating circumstances.

Graduate students may extend the five-week deadline with the explicit approval of the faculty member in charge. To complete an Incomplete after the five-week deadline, graduate students must petition the dean for graduate education. A final grade will not be posted until an approved petition is received in the Registrar's Office.

The instructor is required to submit an Instructor's Report Form for a grade of I reported for an undergraduate. On the form, the instructor provides the date by which the outstanding work is to be completed and a default final grade. The default final grade represents the grade the student would have earned, using appropriately low scores for the missing work. If the subject has not been completed by Add Date of the succeeding regular term, the default final grade will be posted to the student's record unless a later deadline has been specifically agreed upon by the instructor and the student.

No grade of I can be assigned to any undergraduate in the term in which he or she graduates. All grades of Incomplete must be resolved prior to graduation.

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

U Notation for thesis work that has not been completed and in which progress has been unsatisfactory. Grade given upon completion of the work in a later term also covers this term. Faculty members must obtain approval from the Committee on Curricula or the Graduate Academic Performance Group to use the grade of J in subjects other than those mentioned above.

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

Other Notations. The following notations are also used on the academic record.

S Notation for credit awarded for work done elsewhere.
SA Notation for satisfactorily completed doctoral thesis. Doctoral theses are not graded.
Part 74

are no pending disciplinary actions.

awarded unless all financial obligations to the Institute are clear and there

session, as established in the academic calendar. A degree will not be

departmental committees.

or the Committee on Graduate School Programs on recommendations from

action is based upon approval by the Committee on Academic Performance

Degrees are awarded by the Corporation of the Institute in September,

available in an unofficial version free of charge or in an official version at

at $8 per copy. Students wishing to request a copy of

calculations of grade point averages.

grades below may be authorized. These grades are not included in the

http://web.mit.edu/transcripts/their academic record should see the Registrar's Office website,

available in the Undergraduate Education section.

Grade Reports and Transcripts

Students may view their internal grade reports on WebSIS. Transcripts are

available in an unofficial version free of charge or in an official version at

a cost currently set at $8 per copy. Students wishing to request a copy of

their academic record should see the Registrar's Office website,

http://web.mit.edu/transcripts/.

Graduation

Degrees are awarded by the Corporation of the Institute in September,

February, and June upon recommendation of the Faculty. Favorable faculty

action is based upon approval by the Committee on Academic Performance

or the Committee on Graduate School Programs on recommendations from
departmental committees.

Students must submit an online SB degree application or advanced

degree application by the deadline for each regular term or the summer

session, as established in the academic calendar. A degree will not be

awarded unless all financial obligations to the Institute are clear and there

are no pending disciplinary actions.

More information is available at http://web.mit.edu/registrar/graduation/index.html

INSTITUTE REGULATIONS

Policies and Procedures

MIT expects that all students come to the Institute for a serious academic

purpose and expects them to be responsible individuals who conduct
themselves with high standards of honesty and personal conduct.

Disappointments in this expectation have been rare. It is MIT's policy to

maintain rules and regulations consistent with efficient administration and

the general welfare of the MIT community.

Fundamental to the principle of independent learning and professional

growth is the requirement of honesty and integrity in conduct of one's

academic and nonacademic life. Maintenance of a healthy living and

learning environment requires that all members of the community exercise
due respect for the basic rights of one another.

Academic Integrity

Cheating, plagiarism, unauthorized collaboration, and other forms of aca-
demic dishonesty are considered serious offenses for which disciplinary

penalties can be imposed.

Early in the term, the instructor should communicate specific expecta-
tions regarding academic conduct and collaboration in the subject. See the

information on Term Regulations earlier in this section.

Some academic offenses by students can be handled directly between

the faculty member and the students involved. In some cases, it may be

necessary for the department head to review, or otherwise to assist in, the

resolution of the matter. When a dispute cannot be resolved satisfactorily

within the department, or if it seems appropriate, a complaint against a

student can be brought to the Committee on Discipline as explained in the

section on Complaint and Disciplinary Procedures.

The Academic Integrity Handbook, a guide for students published by

the Office of the Dean for Undergraduate Education, contains additional

information that may be helpful to students and faculty (http://web.mit.
edu/academicintegrity/).

Institute Policy on Harassment

Harassment of any kind is not acceptable behavior at MIT; it is inconsistent

with the commitment to community that characterizes MIT's activities.

MIT is committed to creating an environment in which every individual can

work, study, and live without being harassed. Harassment may there-

fore lead to sanctions up to and including termination of employment or

student status.

Harassment is any conduct, verbal or physical, on or off campus, that

has the intent or effect of unreasonably interfering with an individual's

or group's educational or work performance at MIT or that creates an

intimidating, hostile or offensive educational, work or living environment.

Some kinds of harassment are prohibited by civil laws or by MIT policies on

conflict of interest and nondiscrimination (see relevant sections of Policies

and Procedures).

Harassment on the basis of race, color, gender, disability, religion,
national origin, sexual orientation or age includes harassment of an indi-

vidual in terms of a stereotyped group characteristic, or because of that

person's identification with a particular group.
Sexual harassment may take many forms. Sexual assault and requests for sexual favors that affect educational or employment decisions constitute sexual harassment. However, sexual harassment may also consist of unwanted physical contact, requests for sexual favors, visual displays of degrading sexual images, sexually suggestive conduct, or offensive remarks of a sexual nature.

The Institute is committed under this policy to stopping harassment and associated retaliatory behavior. All MIT supervisors have a responsibility to act to stop harassment in the areas under their supervision.

Any member of the MIT community who feels harassed is encouraged to seek assistance and resolution of the complaint. To implement the policy on harassment, MIT provides a variety of avenues by which an individual who feels harassed may proceed, so that each person may choose an avenue appropriate to his or her particular situation. Institute procedures are intended to protect the rights of both complainant and respondent, to protect privacy, and to prevent supervisory reprisal.

MIT’s policy on harassment appears in the guide Dealing with Harassment at MIT, which is available on the website at http://web.mit.edu/communications/hg/. General complaint procedures are described in MIT Policies and Procedures, Section 9.6, and on the website at http://web.mit.edu/policies/g/9.6.html.

**Institute Policy on Hazing**

In accordance with Massachusetts state law (Chapter 269:17–19), the Institute has adopted the following policy statement on the crime of hazing:

The term ‘hazing’ shall mean any conduct or method of initiation into any student organization, whether on public or private property, which willfully or recklessly endangers the physical or mental health of any student or other person. Such conduct shall include whipping, beating, branding, forced calisthenics, exposure to the weather, forced consumption of any food, liquor, beverage, drug or other substance, or any other brutal treatment or forced physical activity which is likely to adversely affect the physical health of any student or other person, or which subjects such student or other person to extreme mental stress, including extended deprivation of sleep or rest or extended isolation.

Pursuant to the law, “any person who is identified as a principal organizer or participant in the crime of hazing shall be punished by a fine of not more than three thousand dollars or by imprisonment for not more than one year, or both.”

[Any person who] knows that another person is the victim of hazing as defined [above] and is at the scene of such crime shall, to the extent that such person can do so without danger or peril to himself or others, report such crime to [MIT Police or] an appropriate law enforcement official as soon as reasonably practicable. [Any student who] fails to report such crime shall be punished by a fine of not more than $1,000.

The Office of Student Life Programs or the Department of Athletics, Physical Education and Recreation will provide a copy of the law to the heads of all groups, teams and student organizations. Each group, team or organization shall distribute a copy of the law to each of its members, plebes, pledges or applicants for membership. It shall be the duty of each such group, team or organization, acting through its designated officer, to deliver annually to the Office of Student Life Programs (with exception of varsity teams and club sports, that may deliver acknowledgements to the Department of Athletics, Physical Education and Recreation) an acknowledgment stating that such group, team or organization has received a copy of the law, that each of its members, plebes, pledges, or applicants has received a copy of the law, and that such group, team or organization understands and agrees to comply with the provisions of this section and sections 17 and 18. Copies of the law are available at the Office of Student Life Programs and the Department of Athletics, Physical Education and Recreation.

MIT considers acts of hazing to be extremely serious offense to the community and will treat offenders accordingly. The Institute considers the practice of “showering,” in which students are placed in the shower against their will by other individuals, as a form of hazing; therefore, “showering” is prohibited.

**Other Personal Conduct**

All members of the MIT community are expected to conduct themselves with proper respect for one another and for each other’s property.

MIT expects that members of the Institute community will not engage in behavior that endangers their own sustained effectiveness or that has serious ramifications for their own safety, welfare, academic well-being, professional obligations, or that of others. In situations where an individual student’s physical illness or emotional difficulties affect not only the student, but also others in the community, it is the Institute’s responsibility to consider the well-being of the community as well as the individual in care decisions.

Improper use of Institute property or facilities, including keys, computers, telephones, and so forth, or misuse of MIT’s name, or violation of Institute regulations, may result in disciplinary proceedings within the Institute, or legal proceedings outside of MIT, or both.

Off-campus misconduct may be a basis for MIT action if the Institute considers that such misconduct impinges on the well-being or functioning of the Institute. The Institute reserves the right to determine its jurisdiction on a case-by-case basis. Student status in no sense renders an individual student immune from the jurisdiction of civil or criminal courts and other governmental authorities. MIT actions will take into account applicable law as well as the policies and procedures of the Institute and the standards of behavior expected of members of the educational community.

MIT handles internally some incidents that might give rise to civil or criminal liability. This is done with the understanding by the outside community that MIT deals seriously with such offenses. As is the case for many universities, local authorities often rely on MIT to resolve such issues as long as the internal policies and procedures are effective and adequate. MIT action by itself, however, does not preclude the possibility of other judicial remedy.

If an infraction causes a student to be involved both in Institute disciplinary proceedings and in criminal proceedings, and if an Institute decision might prejudice the court case, the Institute will usually hold its final decision in abeyance until after the criminal proceedings have been concluded.

For more information, contact the Office of Student Citizenship (OSC), Room W20-507, 617-253-7848.
Complaint and Disciplinary Procedures

Students who believe that they have been treated improperly for any reason are encouraged to raise their concerns. Difficulties with other students can be pursued within the living group, department head, other appropriate venues or groups, or the Office of Student Citizenship (OSC), Room W20-507, 617-253-7848. Students may also bring concerns to the attention of an ombudsperson in the Office of the President. It is Institute policy that individuals will not be reprimanded or discriminated against for initiating an inquiry or complaint and that the rights of the individual against whom a complaint is made will be protected.

Anyone in the MIT community—including individual students, faculty members, and employees of the Institute—may bring a formal complaint against a student to the Committee on Discipline (COD). The COD reviews cases of academic offenses, violations of Institute regulations and standards, and other infractions alleged to have been committed by students.

A formal complaint against a student must be submitted in writing to OSC. The charge and its documentation are transmitted to the chair of the COD. After a review of the documentation, the chair will decide whether or not a hearing by the COD is warranted, and, if so, what the appropriate forum will be. The COD has the authority to impose any sanction it deems appropriate. Possible sanctions include placing a letter in a student’s disciplinary file, informal probation, formal probation, suspension, and expulsion. Sanctions may also include educational and/or restorative components meant to address the wrongdoing and serve the larger community. Detailed procedures are available at [http://web.mit.edu/committees/cod/](http://web.mit.edu/committees/cod/).

This procedure serves also as the grievance procedure for students as required by Title IX of the Higher Education Act of 1972 with regard to grievances arising out of alleged discrimination on the basis of sex, and for disabled students alleging failure to comply with Sections 503 and 504 of the Rehabilitation Act of 1973, and the Americans with Disabilities Act of 1990. Inquiries concerning the Institute’s policies and compliance with applicable laws, statutes, and regulations (such as Title IX and Section 504) may be directed to the vice president for human resources, Room E19-291, 617-253-6512.

A complaint against anyone employed by MIT may go to the immediate or higher supervisor of the apparent offender, or to the Human Resources Office on campus or at Lincoln Laboratory.

A description of the complaint procedures for persons employed at MIT is included in Policies and Procedures. Refer to the guide Dealing with Harassment at MIT for the rules and regulations of the COD as well as procedures for formal hearings of the Office of the Dean for Student Life. Both publications are available in the Information Center, Room 7-121, and on MIT’s website.

Voter Registration

Voter registration forms and instructions are available in the Student Services Center, Room 11-120, and at the registration location on fall and spring term Registration Day.

Privacy of Student Records

MIT’s Student Information Policy governs the circumstances under which, and the persons to whom, student information may be disclosed, as well as students’ rights to access their own records and to challenge their accuracy. As required by federal law, this policy includes the rights and privacy protections provided by the Family Educational Rights and Privacy Act (Title 20, US Code, section 1232g, often referred to as “FERPA” or the “Buckley Amendment”).

The following summarizes in general terms the major student rights under FERPA. For more detailed information, the policy in its entirety should be consulted. The full text of MIT’s Student Information Policy may be found on the web at [http://web.mit.edu/policies/11/sip.html](http://web.mit.edu/policies/11/sip.html), or in printed form at the MIT Libraries and at the MIT Information Center, Room 7-121.

Education Records

Under FERPA, education records include most tangible materials, including computer records, maintained by MIT that relate directly to an identifiable student currently or formerly enrolled at MIT. These include admissions records, grades, most coursework, exams, UROP records, disciplinary records, and financial aid records, as well as gender, nationality, race, ethnicity, and identification photographs. Education records do not include directory information, as described below, or those records of Institute faculty and staff members that are made for, and restricted to, their personal use. Other kinds of information, such as medical and law enforcement records, are also excluded from the definition of education records. These are sometimes governed by other laws and/or policies.

Disclosure

Under FERPA, a student has the right to consent to disclosures of personally identifiable information contained in the student’s education records, except to the extent that it authorizes disclosure without consent.

Disclosure Within MIT. Under one FERPA exception, individually identifiable information contained in a student’s education records may, without the student’s consent, be disclosed within MIT to Institute officials with a legitimate educational interest, meaning officials who need that specific information in order to fulfill their professional responsibilities. A school official is a person employed by the Institute in an administrative, supervisory, academic, or research, or support staff position (including law enforcement unit personnel and health staff); a person or company with whom the Institute has contracted (such as an attorney, auditor, or collection agent); a person serving on the MIT Corporation; or a student serving on an official committee, or assisting other school officials in performing their tasks. In addition, victims of crimes of violence will be informed of the outcomes of disciplinary proceedings about those incidents.

Disclosure Outside MIT. As a general rule, individually identifiable information contained in a student’s education records may be disclosed to persons outside MIT only with the student’s prior, written consent. MIT discloses education records without a student’s consent to other schools in which the student seeks enrollment or is enrolled. The student has the right, upon request, to a copy of the records disclosed to another school. Although parents normally are not entitled to review students’ education records without the students’ consent, appropriate MIT representatives
may consult with parents and others in emergencies when health and
safety issues so require. Disclosure may also be made without consent to
government agencies or in accordance with legal process only to the extent
required by law.

Directory Information. A student’s name, term and permanent home
addresses, MIT office address, term phone number, term email address,
Course, year and registration type, degrees received, dates of attendance,
date of birth, honors and awards received, and for an intercollegiate athlet-
ic team member, height and weight, is designated as a student’s “directory
information.” This information may be disclosed within and outside of MIT
without a student’s consent. Students have the right to require that some
or all of their directory information not be disclosed (except as otherwise
permitted under FERPA) by following the instructions on WebSIS. In order
to prevent publication in the printed Student Directory published each fall
this request must be made at the very beginning of the fall term.

Students’ Access to Their Own Records
A student has the right to review his or her own education records
within 45 days after making a written request to the department or unit
that maintains the records, to the registrar, to the Office of the Dean
for Undergraduate Education, or to the Office of the Dean for Graduate
Education, identifying the records the student wishes to inspect. The
appropriate MIT official will make arrangements for access and notify the
student of the time and place where the records may be inspected. If the
records are not maintained by the MIT official to whom the request was
submitted, that official shall advise the student of the correct official to
whom the request should be addressed. The right to access includes the
right to obtain copies. The right does not, however, extend to portions of a
student’s education records that relate to other identifiable students.

Correction of Records
A student has the right to request the amendment of information in his or
her education records that the student believes is inaccurate or mislead-
ing. Such a request may be made to the custodian of the record, to the
Office of the Dean for Undergraduate Education, or to the Office of the
Dean for Graduate Education and should clearly identify the part of the re-
cord the student wants changed, and state why it is inaccurate or mislead-
ing. If the requested amendment is not made, MIT will notify the student of
this decision and that the student has the right to a hearing concerning the
requested amendment. Additional information on the hearing procedures
will be provided to the student when he or she is notified of the right to a
hearing. If the correction is not made as a result of the hearing, the student
may include his or her own statement in the record. Because grades and
evaluations are the result of academic judgment, they are not subject to
this type of challenge.

Right to File Complaint
A student has the right to file a complaint with the US Department of
Education concerning alleged failures by MIT to comply with the require-
ments of FERPA. The name and address of the office that administers FERPA
is: Family Policy Compliance Office, US Department of Education, 400
Maryland Avenue, SW, Washington DC, 20202-5920.
Part 2  Schools and Courses
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Architecture 83
Media Arts and Sciences 91
Urban Studies and Planning 92

School of Engineering

Aeronautics and Astronautics 105
Biological Engineering 118
Chemical Engineering 124
Civil and Environmental Engineering 134
Electrical Engineering and Computer Science 143
Engineering Systems 153
Materials Science and Engineering 160
Mechanical Engineering 167
Nuclear Science and Engineering 182

School of Humanities, Arts, and Social Sciences

Anthropology 192
Comparative Media Studies 194

Economics 197
Foreign Languages and Literatures 201
History 204
Humanities 206
Linguistics and Philosophy 209
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The School of Architecture and Planning is an extraordinarily complex, diverse, sometimes contentious, always evolving and transforming place. Some shared values, however, give the School its unique character. We are committed to sustaining and enhancing the quality of the human environment at all scales, from the personal to the global. We value design excellence, technological inventiveness, and imaginative scholarship. And we believe that design and policy interventions should be grounded in unwavering commitment to equity, social justice, and making a positive difference in the everyday lives of real people.
The School of Architecture and Planning is made up of five main divisions—the Department of Architecture, the Department of Urban Studies and Planning, the Media Lab, the MIT Center for Real Estate, and the Program in Art, Culture, and Technology.

The unifying theme of all our activities is design. Through the design of physical spaces, and through the design of policies and technologies that shape how those spaces are used, we aim to sustain and enhance the quality of the human environment at all scales, from the personal to the global.

We believe that design and policy interventions should be grounded in a commitment to improving individual human lives, equity and social justice, cultural enrichment, and the responsible use of resources through creative problem solving and project execution.

Students

The School of Architecture and Planning enrolls an average of 600–700 students a year in a collection of courses ranging from Renaissance architecture to the cities of tomorrow, digital fabrication, motion graphics, shape grammars, photography, and construction finance. By far the largest number of those students enter our graduate programs and many of them also pursue cross-disciplinary studies and dual degrees among those programs and others at the Institute.

Throughout the years, we have been noted for the diversity of our student body, drawing on candidates from around the world and from all walks of life. The Department of Architecture graduated its first woman, Sophia Hayden, in 1890, and three years later, Robert Taylor became the first African-American to graduate from an American architecture program—a tradition of inclusiveness that continues today.

Global Projects

One of MIT’s founding principles is the belief that professional competence is best fostered by focusing teaching and research on real problems in the real world, and at the School of Architecture and Planning we take that mandate very seriously.

Accordingly, a central aspect of our teaching and research is our ongoing participation in global initiatives—many of them collaborative undertakings among our five divisions, with other divisions of MIT, and with public and private institutions in the US and abroad.

As a result of this commitment, it is fair to say that the faculty and students of the school are truly citizens of the world—engaged in the problems facing countries at all stages of development, taking part in the public discussion of issues on a global scale, studying, developing and applying best practices all around the world.

To enhance collaboration among the School’s divisions and with other divisions at MIT, a major new facility was opened in the spring of 2010, designed by Fumihiko Maki, winner of the Pritzker Prize in 1993. Adjacent to and part of the School’s legendary Media Lab—designed by alumnus I. M. Pei (1940 BArch), also a Pritzker Prize winner—the facility houses an array of cutting-edge work in media, art, and technology, building on synergies among the building’s tenants.

History

Our history stretches back nearly a century and a half, providing our current students with a legacy and long tradition of pioneering excellence. The Department of Architecture was the first such department in the nation (1865) and became a leader in introducing Modernism to America. The program in city planning was the second of its kind in the country (1932), later evolving into the current Department of Urban Studies and Planning, the longest continuous planning program in the United States and repeatedly ranked number one in the nation.

The Media Lab, the birthplace of multimedia computing (1985), has come to be known around the world as a world-class incubator of new design ideas; the Center for Real Estate established the nation’s first one-year graduate program in real estate development (1984); and the Center for Advanced Visual Studies (1967), now part of the new Program in Art, Culture, and Technology, pioneered the use of technologies such as lasers, plasma sculptures, sky art, and holography as tools of expression in public and environmental art.

Resources

The Rotch Library is one of the nation’s premier resources in architecture and planning, offering extensive depth in architecture, building technology, art history, photography, environmental studies, land use, urban design, housing and community development, regional planning, urban transportation and real estate. Its visual collections hold more than 60,000 digital images and 380,000 slides.

The School’s Wolk Gallery mounts several shows a year in its exhibition space, overseen by the curator of architecture and design at the MIT Museum. The Keller Gallery, a vest-pocket space of about 200 square feet, shows a steady stream of faculty, student, and experimental work, including work from alumni and friends. The PLAZmA Digital Gallery is an electronic showcase of work and events on display in the School’s public areas, featuring faculty and student work.

The MIT Museum frequently features exhibits on architecture and visual studies in its main galleries at 265 Massachusetts Avenue, as well as in its Compton Gallery, located in the heart of campus under the big dome. The Museum’s eGallery, a virtual exhibition space and archive, features sites designed specifically as virtual exhibitions, spotlighting museum collections as well as exhibitions no longer on display in its galleries.

The List Visual Arts Center, three galleries on the first floor of the Media Lab’s Wiesner Building, presents 5–8 shows a year exploring contemporary artmaking in all media. Rotch Library also features exhibits of student, staff and faculty work, as well as shows from its collections, in its space in Building 7-238.

The School’s newsletter, PLAN, is published in print and online by the Dean’s Office, Room 7-231. The five divisions of the School can be contacted directly about their lineup of publications.
### Degrees Offered in the School of Architecture and Planning

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<th>Course 4</th>
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<tbody>
<tr>
<td>SB</td>
<td>Architecture</td>
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<tr>
<td>SB</td>
<td>Architecture Studies</td>
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<tr>
<td>MArch</td>
<td>Architecture</td>
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<tr>
<td>SMArchS</td>
<td>Architecture Studies</td>
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<tr>
<td>SMACT</td>
<td>Art, Culture and Technology</td>
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<tr>
<td>SMBA</td>
<td>Building Technology</td>
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<tr>
<td>PhD</td>
<td>Architecture: Building Technology</td>
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<td>PhD</td>
<td>Architecture: Design and Computation</td>
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<tr>
<td>PhD</td>
<td>Architecture: History and Theory of Architecture</td>
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<td></td>
<td>Architecture: History and Theory of Art</td>
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<tr>
<td>Dual Degrees</td>
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<tr>
<th>Media Arts and Sciences</th>
<th>Course MAS</th>
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<tr>
<td>SM</td>
<td>Media Technology</td>
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<tr>
<td>SM</td>
<td>Media Arts and Sciences</td>
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<tr>
<td>PhD</td>
<td>Media Arts and Sciences</td>
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<table>
<thead>
<tr>
<th>Urban Studies and Planning</th>
<th>Course 11</th>
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</thead>
<tbody>
<tr>
<td>SB</td>
<td>Planning</td>
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<tr>
<td>MCP</td>
<td>City Planning</td>
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<tr>
<td>SM</td>
<td>Urban Studies and Planning</td>
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<tr>
<td>PhD</td>
<td>Urban and Regional Planning</td>
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<tr>
<td>PhD</td>
<td>Urban and Regional Studies</td>
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<tr>
<td>Dual Degrees</td>
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<tr>
<td>Certificates</td>
<td>Urban Design, Environmental Planning</td>
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<tr>
<th>Center for Real Estate</th>
<th>MSRED Real Estate Development</th>
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### Notes

Many departments make it possible for a graduate student to pursue a simultaneous master’s degree.

Several departments also offer undesignated degrees, which lead to the Bachelor of Science without departmental designation. The curricula for these programs offer students opportunities to pursue broader programs of study than can be accommodated within a four-year departmental program.
The Department of Architecture conceives of architecture as a multidisciplinary field of study as well as a means to a professional career in architecture or other design-related careers. Semi-autonomous, degree-granting “discipline groups” and research programs provide an architectural education that is the foundation for complex fields of study. Each group and program supports the others, and all contribute to a mutual enterprise. Students learn methodologies and techniques of working that draw upon the whole range of resources that architecture affords in defining the expansive problems of the built environment and its associated cultures and contexts, as well as in proposing effective solutions through the medium of design. The discipline groups are Architectural Design; Building Technology; Computation; History, Theory and Criticism of Architecture and Art (HTC); and the Program in Art, Culture and Technology (ACT). The Aga Khan Program in Islamic Architecture (AKPIA) is a research group offering its own Master of Science in Architecture Studies and a PhD in association with HTC.

The varied disciplines of the department support substantial research activity. Moreover, the department’s setting within MIT permits greater depth in such technical areas as computation, new modes of design and production, materials, structure, energy, and issues of globalization in architecture as well as in the arts and humanities.

The department offers seven degree programs: the Bachelor of Science in Architecture (BSA), Bachelor of Science in Architecture Studies (BSAS), Master of Architecture (MArch), Master of Science in Architecture Studies (SMArchS), Master of Science in Building Technology (SMBT), Master of Science in Art, Culture and Technology (SMACT), and the Doctor of Philosophy (PhD). The BSA, SMArchS, and PhD programs offer concentrations in multiple research streams.

Architectural Design is taught from a broad range of perspectives linking several common concerns: site and context, use and form, building methods and materials, design methodologies, and the role of the architect in a changing society and world.

Diverse architectural design studios are offered at both the undergraduate and graduate levels. The undergraduate studio sequence begins with instruction in design fundamentals and continues with design projects of increasingly complexity. Entering graduate students enroll in a three-term core program that is tightly integrated with complementary courses in design skills, design precedents, and materials and construction. Advanced “option” studios give graduate students the opportunity to broaden their experience of contexts for design, sharpen their skills, and develop their own attitudes and positions toward architecture. In thesis, a student develops a strategy for a comprehensive building and urban-scale proposal or design research inquiry that is carried out as an independent, critical project—from concept to completion—under the guidance of an advising committee.

Computer resources for educational purposes are distributed in the laboratories and studios of the department and overseen by the staff of the School of Architecture and Planning’s computer resources office. Students are required to learn the fundamentals of computer-aided visualization. Other computer subjects and studio work permit further experimentation with modeling techniques, graphic representations, design methods, technical analysis, prototyping, and assistance with the design process.

The work of the Architectural Design faculty extends beyond the studio. Workshops, lectures, seminars, and research engage the built environment, the forces that mold it, and the design process itself. The work of the faculty covers such areas as urbanism, climate change and sustainable design, computation and design, materials and fabrication, theoretical design research, and housing and settlements in the global context. Central to these topics is the role of the user as an active force in the development of environments and the role of the designer as an agent in the process of human habitation.

In the United States, most state registration boards require a degree from an accredited professional degree program as a prerequisite for licensure. The National Architectural Accrediting Board (NAAB), which is the sole agency authorized to accredit US professional degree programs in architecture, recognizes three types of degrees—the Bachelor of Architecture, Master of Architecture, and Doctor of Architecture. A program may be granted a six-year, three-year, or two-year term of accreditation depending on the extent of its conformance with established educational standards.

A preprofessional undergraduate degree and a professional graduate degree, when earned sequentially, constitute an accredited professional education. However, the preprofessional degree is not, by itself, recognized as an accredited degree.

The Department of Architecture offers the Master of Architecture (MArch) degree in three and one-half years. In exceptional circumstances, a student may be admitted with “advanced entry” and complete the program in two and one-half years, subject to prior academic qualifications in architecture. These professional degrees are structured to educate those who aspire to registration and licensure as architects.

The undergraduate Bachelor of Science in Architecture is a preprofessional degree program. It is useful for those wishing a foundation in the field of architecture as preparation for either continued education in a professional degree program or for employment options in fields related to architecture.

The Architectural Design area of study offers a concentration within the Bachelor of Science in Architecture degree program as well as Master of Architecture and Master of Science in Architecture Studies degrees.

Building Technology includes teaching and applications of the fundamentals of technology as well as research in technology for the next generation of buildings. Topics include building structures, materials, appropriate technology for developing countries, sustainable design, indoor air quality, daylighting, building ventilation, heating and cooling systems, energy use and material flows in urban areas, and development of computational methods for research and design through visualization of building performance in its many aspects. Through lecture subjects, laboratories, workshops, and independent research projects, students may study problems of energy resources and technologies and use this knowledge to design physical environments or buildings that embody current research concepts. Research facilities include a full-scale indoor environmental chamber, and computer workstations. Research facilities of other departments such as Mechanical Engineering and Civil and Environmental Engineering are also used in joint research projects.

This area of study offers a concentration within the Bachelor of Science in Architecture degree program as well as a Master of Science
in Building Technology (SMBT), a Master of Science in Architecture Studies (SMArchS), and a doctoral degree with emphasis on building technology.

The Computation group teaches diverse subjects dealing with theory, history, methods, and applications of computation and digital technology. The aim is to cover the many facets of a rapidly changing and growing area with in-depth, agenda-setting research and teaching. Topics taught cover the description, generation, evaluation, and construction of architectural and urban design through computational means that include computer visualization and modeling, generative theories, software for design synthesis and analysis, and digital fabrication and construction processes and technologies. Students are encouraged to acquire both the technical skills and the theoretical and conceptual foundations to rethink and challenge the limits of current design processes and practices, and to consider the social and cultural implications of their positions.

This area of study offers a concentration within the Bachelor of Science in Architecture degree program as well as a concentration in the Master of Science in Architecture Studies (SMArchS) program and a doctoral program. SMArchS and PhD students are encouraged to take subjects in other relevant departments as a means to explore and develop their interests.

The History, Theory and Criticism of Architecture and Art (HTC) group teaches subjects that deal with the history of architecture and art, as well as the theoretical and political presuppositions informing that history. Offerings range in content and method. Some are motivated by questions derived from the problems of contemporary practice. Others work with a body of historical material investigated in ways that develop analytical skills applicable to a wide range of topics. Still others explore themes (e.g., Orientalism, ornament, sustainability) in their historical and theoretical dimensions. Subjects are taught from the Renaissance to the present, with a special emphasis on topics of modern art and architecture, and focus on materials that are both abstract and concrete, with scales that range from the architectural drawing to the art installation to the urban environment. There is a special emphasis on topics of modern art and architecture in Europe as well as the Americas, with a comparable set of offerings on the Islamic

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**Bachelor of Science in Architecture/Course 4**

<table>
<thead>
<tr>
<th>General Institute Requirements (GIRs)</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td></td>
<td></td>
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<tr>
<td>Humanities, Arts, and Social Sciences Requirement [one subject can be satisfied by a subject in the Departmental Program]</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>2</td>
<td>1</td>
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<tr>
<td><strong>Total GIR Subjects Required for SB Degree</strong></td>
<td>17</td>
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</tbody>
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<thead>
<tr>
<th>Communication Requirement</th>
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<tbody>
<tr>
<td>The program includes a Communication Requirement of 4 subjects:</td>
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<tr>
<td>2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 subjects designated as Communication Intensive in the Major (CI-M).</td>
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<tr>
<td><strong>PLUS Departmental Program</strong></td>
<td></td>
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<tr>
<td>Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics)</td>
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<tr>
<td><strong>Required Subjects</strong></td>
<td>57–60</td>
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<tr>
<td>4.111 Introduction to Architecture and Environmental Design, 12, HASS-A</td>
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<tr>
<td>or 4.11A Introduction to Architecture and Environmental Design Intensive, 9, HASS-A</td>
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<tr>
<td>4.112 Architecture Design Fundamentals I, 12</td>
<td></td>
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<tr>
<td>4.302 Foundations in the Visual Arts and Design for Majors, 12, CI-M</td>
<td></td>
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<tr>
<td>4.401 Architectural Building Systems, 12</td>
<td></td>
<td></td>
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<tr>
<td>4.500 Introduction to Design Computing, 12</td>
<td></td>
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<tr>
<td><strong>Discipline Stream Subjects</strong></td>
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<tr>
<td>By the beginning of their junior year, students are expected to begin concentrating in one of the five discipline streams.</td>
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<tr>
<td>—Architectural Design Discipline Stream</td>
<td>114–117</td>
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<tr>
<td>4.113 Architecture Design Fundamentals II, 15; 4.111*, 4.112</td>
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<tr>
<td>4.114 Architecture Design Studio I, 21, CI-M; 4.113, 4.302, 4.401, 4.500, 4.605</td>
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<tr>
<td>4.115 Architecture Design Studio II, 21; 4.114</td>
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<tr>
<td>4.440 Building Structural Systems I, 12, REST; Calculus II (GIR), 4.401*</td>
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<tr>
<td>4.603 Analysis of Contemporary Architecture, 12, HASS-A</td>
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<tr>
<td>4.605 Introduction to the History and Theory of Architecture, 12, HASS-A</td>
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<tr>
<td>4.116 Architecture Design Studio III, 21; 4.115, 4.440</td>
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<tr>
<td>or Two subjects from any one of the other four discipline streams</td>
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<tr>
<td>—Building Technology Discipline Stream</td>
<td>120</td>
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<tr>
<td>4.411 D-Lab Schools: Building Technology Laboratory, 12, LAB; Physics I (GIR), Calculus I (GIR)</td>
<td></td>
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<tr>
<td>4.440 Building Structural Systems I, 12, REST; Calculus II (GIR), 4.401*</td>
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<tr>
<td>4.504 Introduction to the History and Theory of Architecture, 12, HASS-A</td>
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<tr>
<td>4.7TH Thesis Research Design Seminar, 12, CI-M</td>
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<tr>
<td>4.7TH Undergraduate Thesis, 12, 4.7TH*</td>
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<tr>
<td>Four additional subjects in Building Technology</td>
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<tr>
<td>One additional subject from any of the other four discipline streams</td>
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<tr>
<td>—Computation Discipline Stream</td>
<td>120</td>
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<tr>
<td>4.501 Digital Design and Fabrication, 12; 4.500</td>
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<tr>
<td>4.503 Advanced Visualization: Architecture in Motion Graphics, 12; 4.500*</td>
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<tr>
<td>4.504 Design Scripting, 12; 4.500</td>
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<tr>
<td>4.505 Introduction to the History and Theory of Architecture, 12, HASS-A</td>
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<tr>
<td>4.7TH Thesis Research Design Seminar, 12, CI-M</td>
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</tr>
<tr>
<td>4.7TH Undergraduate Thesis, 12, 4.7TH*</td>
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<tr>
<td>Two additional subjects in Computation</td>
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<tr>
<td>—History, Theory and Criticism of Architecture and Art Discipline Stream</td>
<td>120</td>
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<tr>
<td>4.601 Introduction to Art History, 12, HASS-A</td>
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<td>4.605 Introduction to the History and Theory of Architecture, 12, HASS-A</td>
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<td>4.602 Modern Art and Mass Culture, 12, HASS-A, CI-H</td>
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<tr>
<td>or 4.641 19th-Century Art, 12, HASS-A</td>
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<tr>
<td>or 4.651 Art Since 1940, 12, HASS-A</td>
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world developed by AKPIA and taught within the HTC group.

HTC offers a concentration within the Bachelor of Science in Architecture degree program and a HASS concentration and minor in the history of architecture that are open to all MIT undergraduates. Students in the SMArchS program may choose to concentrate in HTC, and those in the AGA Khan Program for Islamic Architecture (AKPIA) at MIT are dedicated to the study of architecture, urbanism, architectural history, landscape, and conservation in the Islamic world. The program prepares students for careers in research, design, and teaching. Topics covered in its curriculum include critical study of the history and historiography of Islamic architecture; the interaction between architecture, society, and culture; strategies of urban and architectural preservation; and environmental and material-sensitive landscape and design research.

Established in 1979, AKPIA offers students a concentration in Islamic art, architecture, and urbanism as part of the two-year SMArchS degree and the PhD program in HTC. Undergraduates may concentrate in Middle Eastern Studies using subjects offered by AKPIA. The program also has links with the City Design and Development and Environmental Planning and Policy programs in the Department of Urban Studies and Planning, the Aga Khan Programs at Harvard, and ArchNet.

The Program in Art, Culture and Technology (ACT) offers a diverse range of subjects in artistic practice and operates as a learning laboratory for artistic production within the context of an advanced technological community. Students explore the role of art in society and consider artistic practice as knowledge production. Collaborative and individual investigations, artistic research, and transdisciplinary studies are structured in thematic clusters and realized through performance, sound and video, photography, and experimental media and new genres. The program emphasizes art that engages public spheres, the production of space, and networked cultures. ACT addresses context and display and questions the relationship of art to the environment, gender, and social stratification. Extracurricular activities include a cross-disciplinary lecture series, field trips, workshops, studio visits, and public presentations.

ACT offers a concentration within the Bachelor of Science in Architecture degree program and a HASS minor and concentration in art, culture, and technology. It also offers a graduate program leading to a Master of Science in Art, Culture and Technology (SMACT).

More information about the Department of Architecture and its programs can be found at http://architecture.mit.edu/.

UNDERGRADUATE STUDY

The Department of Architecture offers two undergraduate courses of study. They provide a broad undergraduate education for students who have clear professional goals and for those who desire a solid foundation for a number of possible careers. Course 4 leads to the Bachelor of Science in Architecture, and Course 4-B leads to the Bachelor of Science in Architecture Studies.

Bachelor of Science in Architecture/Course 4

Course 4 offers a flexible program for students in five possible discipline streams: art, culture and technology; architectural design; building technology; design and computation; and history, theory and criticism of architecture and art. Within a clear framework, students develop individual courses of study best suited to their needs and interests.

The requirements for the SB in Architecture (BSA) curriculum begin with an introductory subject, 4.111 Introduction to Architecture and Environmental Design, intended as an exploratory subject for freshmen and an introduction for sophomores. The remaining core subjects include study in the arts, computation, architectural design, building technology, and the history of architecture and art.

Subject requirements for each of the five degree streams can be found at http://architecture.mit.edu/undergraduate-education.html).
Each area of concentration provides a variety of subjects from which to choose as well as an opportunity to get more deeply involved in a particular subfield. Students choose their stream at the end of their sophomore year.

Most BSA candidates choose the architectural design discipline stream, which includes sequential studios. The approach fosters investigation and discussion in the development of sensitivity to the built environment. These sensibilities are linked to values and responsibilities to the community at large. Students in design studios develop technical and analytical skills and learn synthesis and invention using the elements of architectural form: material, structure, construction, light, sound, memory, and place.

The department offers a foreign exchange study program with Delft University of Technology and the University of Hong Kong for architecture design seniors in the fall term. A senior thesis is required in the final year in all of the discipline streams except for architecture design, for which it is optional.

Students who plan to continue their studies in a professional graduate program in architecture must apply for admission to a school offering the Master of Architecture (MArch).

Bachelor of Science in Architecture Studies/Course 4-B

Course 4-B is offered for students who find that their basic intellectual commitments are to subjects within the Department of Architecture but whose educational objectives cut across departmental boundaries. These students may, with the approval of the department, plan a course of study that meets their individual needs and interests while including the fundamental areas within the department. For example, students might create a coherent program combining subjects in Course 4 with subjects in urban studies and planning, comparative media studies, systems analysis, computer science, etc.

As early as possible, students should discuss their interests and intended programs with their advisor and departmental faculty members. A student who wishes to follow Course 4-B must initially register as a Course 4 major and take the expected sophomore subjects. By the end of the sophomore year, the student is expected to submit to the department a proposal that includes a statement of educational goals, a list of subjects to be taken to fulfill these goals (84 units), and a timetable of when the subjects will be taken. When the proposal is approved by the Department of Architecture Undergraduate Curriculum Committee, the student may officially switch to the 4-B major.

The Course 4-B curriculum is similar to Course 4 in requiring six core subjects to be taken primarily in the freshman and sophomore years: 4.111, 4.112, 4.302, 4.401, 4.500, and 4.605. During the junior and senior years, the approved interdisciplinary course of study is pursued. A senior thesis, preceded by 4.THTJ Thesis Research Design Seminar, is required.

Minors

The requirements for a Minor in Architecture are as follows:

- Tier I
  - Two subjects:
    - Introduction to Architecture and Environmental Design
    - Architecture Design Fundamentals I
  - Tier II
    - Three subjects chosen from the following list, with no more than two subjects from either the history of art or the history of architecture:
      - Analysis of Contemporary Architecture
      - Civic Architecture in Islamic History
      - The Architecture of Cairo
      - Renaissance Architecture
      - Religious Architecture and Islamic Cultures
    - Tier III
      - One subject:
        - Seminar in the History of Art and Architecture
      - Other advanced seminar in the history of art and/or architecture, including offerings from Harvard or Wellesley, with permission of the HASS field advisor and the instructor.

The Minor in the History of Architecture and Art, considered a HASS minor, is designed to enable students to pursue study in hands-on artistic practice and critical debate. Undergraduates gain skills and critical understanding in new genre art, including time-based media, public...
GRADUATE STUDY

The Department of Architecture offers five graduate degree programs—the Master of Architecture (MArch), Master of Science in Architecture Studies (SMArchS), Master of Science in Building Technology (SMBT), Master of Science in Art, Culture and Technology (SMACT), and the Doctor of Philosophy (PhD).

The Master of Architecture is awarded to students who complete a program, accredited by the National Architectural Accrediting Board, which is an essential step toward licensure for architectural practice.

The Master of Science in Architecture Studies program stresses research and inquiry in the built environment; the degree is meant both for students who already have their first professional architecture degree and those whose previous education orients them toward nonprofessional graduate study in architecture.

The Master of Science in Building Technology program is run jointly by the Departments of Architecture, Civil and Environmental Engineering, and Mechanical Engineering. This degree program is intended for students interested in pursuing topics of significant technical and engineering depth. The main effort of the student is in an area of original research culminating in a thesis document.

The Master of Science in Art, Culture and Technology focuses on the development of critical and visionary positions of artistic practice and research in the context of an advanced technological and scientific community. Central to the curriculum is the potential for creating links with programs in architecture, urbanism, technology, and media studies, as well as other disciplines at MIT. Students are challenged to expand their artistic practice by questioning the historical, cultural, social, and ethical implications of their work. Discussion in contemporary theory and criticism complements studio production.

The PhD program is an advanced degree program in the areas of History, Theory and Criticism; Building Technology; and Design and Computation.

Master of Architecture

The Master of Architecture is awarded upon the satisfactory completion of an approved program of at least 312 units (96 of which must be in H-level subjects) and an acceptable thesis. The program requires three and one-half academic years of residence.

Advanced entry may be possible for students who have majored in architectural design at a “4 plus 2” architecture school. These students may be considered for completion of the program in two and one-half years depending on their academic experience and accomplishments.

The professional MArch program is diverse and open-ended, with many views of appropriate research and practice of architecture available. Shared concerns include an interest in materials, fabrication, and technology; drawing and geometry; theory and criticism; sustainability and climate change; and culture in an age of rapid change and globalization. They also include a commitment to design as it engages related disciplines aligned with architectural production, a view of the environment as an ecologically structured phenomenon, a regard for the fabrication processes of building, a perspective on new technologies and their impact on practice, and a concern for the spatial, temporal, social, and urban contexts of buildings. Given the varied perspectives from which the curriculum is conceived, an important aspect of the student’s development is to be able to establish links between different areas of focus and its many disciplines.

The focus of the MArch degree program is architecture design studios integrated with supporting subjects central to the curriculum. While the professional curriculum specifies that a student study a range of subjects in several interrelated fields, students in the MArch program have some choice and are required to develop a concentration in a self-determined area. Required and elective subjects taught by the various discipline groups within the department and in other related departments offer a way of charting multiple paths for future professional possibilities. Therefore, students are expected to assume much of the responsibility for structuring their own educational programs at MIT beyond the core curriculum and toward the development of a design thesis.
Master of Science in Architecture Studies
This program is designed to provide a climate for research and inquiry that stresses the investigative component of understanding the built environment. It is open to students with professional degrees in architecture and, more rarely, to other university graduates. The SMArchS degree is awarded upon satisfactory completion of an approved program of study of 96 units (42 of which are H-level subjects) and the completion of an acceptable thesis. The degree requires two full academic years of residency.

About half of the students in the SMArchS program come from outside the United States; this encourages the exchange of ideas across cultures. Students often use a site in their home countries as a base for their theses.

The program has a strong interest in the methods of inquiry, development and testing of knowledge, and the building and application of theory as it pertains to the built environment. It allows students to specialize in areas in which they wish to obtain particular abilities. There are several areas of study and interdisciplinary work is encouraged.

The Architectural Design program nurtures research that contributes to current thinking about design in the field of architecture. It aims to advance architectural design by cultivating lateral thinking between design expertise and a range of allied fields, such as material sciences, media arts and technology, cultural studies, computation, sustainability, and emerging fabrication protocols. The program provides opportunity for designers to explore theoretical foundations of architectural design as well as its pedagogy, and to provide a platform for applied research and new forms of design practice.

In Architecture and Urbanism, design is developed and evaluated as a means to demonstrate the hypothesis that the urban space can be effectively constructed, and made legible and civic, through architecture. Areas of faculty interest include theory of urban form and design, urban ecology, and landscape.

The Aga Khan Program for Islamic Architecture supports a small number of students interested in pursuing research on architecture and urbanism in the Islamic world. Faculty interests include Islamic architectural and urban history and historiography, strategies for landscape and urban preservation, and the critique of contemporary architecture in Islamic countries. The program is open to all students interested in issues related to Islamic architecture.

The Computation group inquires into the varied nature and practice of computation in architectural design and the ways in which design meaning, intention, and knowledge are constructed through sensing, thinking, and making computationally. It focuses on developing innovative computational tools, processes, and theories, and applying them in creative, socially meaningful responses to challenging design problems.

Building Technology focuses on the intersection of design and technical issues for buildings that positively contribute to a more humane and environmentally responsible built world. Research within the group addresses innovative materials and assemblies, low-energy strategies, and structures.

Students in History, Theory and Criticism work alongside doctoral students in the study of architecture and art together with historical and methodological issues that inform or link conceptual and practical work.

In all these areas, related subjects are available in the Department of Urban Studies and Planning, in other departments at MIT, and at Harvard.

Simultaneous Master’s Degrees in Architecture and City Planning
Students admitted to the Department of Architecture can propose a program of joint work in Architecture and Urban Studies and Planning that will lead to the simultaneous award of two degrees. Degree combinations may be MArch/Master in City Planning (MCP) or SMArchS/MCP. All candidates for simultaneous degrees must meet the requirements of both programs, but may submit a joint thesis. A student must apply by January 3 before beginning the last full year of graduate study in architecture. Dual-degree applications are submitted to Sandra Elliott in 10-485. Students are first approved by the Dual-Degree Committee and then considered during the spring admissions process. For more information, contact Sandra Elliott at 617-253-5115.

Urban Design Certificate
The Department of Architecture and the Department of Urban Studies and Planning jointly offer a Certificate in Urban Design. The purpose of the program is to provide the fundamental knowledge and special skills required to design urban and suburban environments. Students in the MArch, SMArchS, MCP, or Master of Science in Urban Studies and Planning programs are eligible for a Certificate in Urban Design if they complete a specific set of subjects drawn from the two departments. For further information, contact Sandra Elliott, Room 10-485, 617-253-5115.

Master of Science in Building Technology
This program provides a focus for graduate students interested in the development and application of advanced technology for buildings. Students in this program take relevant subjects in basic engineering disciplines along with subjects that apply these topics to buildings. The program is open to qualified students with a degree in engineering or in architecture with a substantial background in technology.

The program concentrates on the development of the next generation of technology for buildings as well as the innovative application of state-of-the-art concepts to building systems. Research programs, in many cases jointly carried out with faculty and students in the School of Engineering, include energy efficiency, sustainable building design, controls, natural ventilation and indoor air quality, innovative materials and structures, and computational simulation of building behavior.

The SMBT degree is generally completed in two years and requires 66 units of coursework (42 of which must be H-level graduate credit) and the completion of an acceptable thesis.

Master of Science in Art, Culture, and Technology
ACT operates as a learning laboratory, focusing on artistic research, advanced visual studies, and transdisciplinary collaboration within the context of MIT’s technological community. Students are challenged to explore the role of art and critical design in society and to expand their practice through collaborative and individual
investigations in the areas of performance, sound and video, photography, and experimental media that address context and display. The SMACT curriculum includes courses in the production of space, networked cultures, and contemporary curatorial practice, among others. Participation in ACT research groups and regular tutorials foster in-depth examination of student work in progress.

The SMACT degree is completed in two years and requires 156 units of coursework (111 of which must be H-level graduate credit) and the completion of an acceptable written thesis. For more information, visit http://act.mit.edu/.

Doctor of Philosophy

The PhD in Architecture may be pursued in one of the following areas: History and Theory of Architecture/History and Theory of Art; Building Technology; or Design and Computation.

The PhD program in History, Theory and Criticism of Architecture and Art emphasizes the study of art, architecture, and urbanism, together with the historical and methodological issues that inform or link conceptual and practical work. The Aga Khan Program for Islamic Architecture is part of this doctoral program.

The doctoral program in Building Technology is interdepartmental, with important components in the Departments of Civil and Environmental Engineering, Electrical Engineering and Computer Science, Mechanical Engineering, and Urban Studies and Planning. Research programs include energy efficiency, sustainable building design, controls, natural ventilation and indoor air quality, daylighting, masonry structures, innovative materials and structures, and computational simulation of building behavior.

The PhD program in Design and Computation is broadly conceived around computational ideas and digital technologies as they pertain to the understanding, description, generation, and construction of architectural form. Research topics include the mathematical foundations of shape and shape representation; generative tools for design synthesis; advanced modeling and visualization techniques; rapid prototyping and CAD/CAM technologies for physical fabrication; and the analysis of the design process and its enhancement through supporting technologies and workspaces. The mission of the program is to enrich design from a computational perspective, with clear implications for teaching and practice.

Admission and degree requirements vary somewhat in the specific areas listed above, and may be obtained from the Department of Architecture website or in correspondence with the separate areas. The residency requirement for the PhD is a minimum of two full academic years. Completion of all of the requirements for the PhD—including the dissertation—is usually accomplished in five years.

Each student admitted to work in the doctoral program should consult closely with one principal professor in his or her area to develop a general plan of study. In all three areas, progress toward the PhD follows a sequence of required subject work, qualifying papers, general examinations, and dissertation research, writing, and defense. Students are encouraged to take subjects appropriate to their study plans in other departments at MIT and at Harvard.

Inquiries
Further information concerning undergraduate and graduate academic programs in the department, admissions, financial aid, and assistantships may be obtained from the Department of Architecture, Room 7-337, 617-253-7387, or from http://architecture.mit.edu/.

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Associate Department Head

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Aga Khan Professor
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**Principal Research Scientist**

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Professor of Structures, Emeritus

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Waclaw Piotr Zalewski, DTechSci
Professor of Structures, Emeritus
The Program in Media Arts and Sciences (MAS) focuses on the invention, study, and creative use of new technologies that change how we express ourselves, how we communicate with each other, how we learn, and how we perceive and interact with the world. The field draws on a number of other disciplines, including computer science, cognitive sciences, communications, design, and the expressive arts. The program offers undergraduate and graduate subjects (listed under MAS in the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi) and a graduate program leading to master’s and doctoral degrees. Its academic programs are intimately linked with the research programs of the Media Laboratory.

**Undergraduate Study**

Most MAS undergraduate subjects are project-oriented and relate to ongoing research within the Media Laboratory. Certain graduate subjects are open to advanced undergraduates (see the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi, for details). Undergraduate Research Opportunities Program (UROP) positions at the Media Lab are a major part of the MAS education offerings to undergraduates. First-year students participating in UROP are encouraged to register for MAS.111 Introduction to Research in Media Arts and Sciences.

The MAS Alternative Freshman Year Program emphasizes project-oriented work and connections to current research topics. Students in it attend mainstream lectures for core freshman subjects but take recitations led by Media Laboratory researchers and participate in research through UROP positions at the Media Lab.

**Graduate Study**

Media Arts and Sciences offers a graduate program leading to master’s and PhD degrees. Graduate students work closely with a research advisor in an apprenticeship relationship. Students enter the program from a wide variety of backgrounds, including electrical engineering, physics, computer science, cognitive science, mechanical engineering, art, and design, and the learning sciences.

For the master’s degree, students are required to spend at least four terms in residence (one of which may be a summer term) and to complete a satisfactory research thesis. Students wishing to pursue a PhD degree must demonstrate exemplary progress in the master’s program and gain approval from a departmental committee review. Requirements for the PhD degree include successful completion of MAS general exams, and successful completion and defense of a dissertation based on original and significant research within one of the Media Lab’s research groups.

**Research Assistantships**

The Program in Media Arts and Sciences offers financial assistance to all successful applicants in the form of research assistantships within the Media Laboratory, which are an important part of the educational program. Research assistants receive academic credit for part of their research activities.

**Inquiries**

Additional information about the programs in Media Arts and Sciences, graduate admissions, research programs, and research assistantships may be obtained from MAS Headquarters, Room E14-245, 617-253-5114, fax 617-253-8542, mas@media.mit.edu.

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**Senior Research Scientist**

Andrew Lippman, PhD

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Barry Vercoe, DM  
Professor of Media Arts and Sciences, Emeritus
The Department of Urban Studies and Planning (DUSP) offers four degree programs: a Bachelor of Science in Planning; a two-year professional Master in City Planning (MCP); a one-year Master of Science in Urban Studies and Planning (reserved for mid-career students); and a PhD in Urban Studies and Planning. In addition, DUSP has other, nondegree programs and affiliations: the Special Program in Urban and Regional Studies (for mid-career professionals from developing countries); the Community Innovators Lab; the Center for Advanced Urbanism, a research-based institution dedicated to implementing new integrative models of design and development for cities; and the SENSEable City Lab, a research center concerned with the relationship between technology and cities. Once students are admitted and enrolled at MIT, it is possible to apply for certificate programs in urban design (offered jointly with the Department of Architecture) or environmental planning.

City and regional planners in the United States and other parts of the world are involved not only in physical and economic development, but also in management of the environmental, social, and design consequences of development. They engage in a variety of activities aimed at shaping the pattern of human settlements, and at providing people with housing, public services, employment opportunities, and other crucial support systems that comprise a decent living environment. Planning encompasses not just a concern for the structure and experience of the built environment, but also a desire to harness the social, economic, political, and technological forces that give meaning to the everyday lives of men and women in residential, work, and recreational settings. Planners operate at the neighborhood, metropolitan, state, national, or international level, in both the public and the private sectors. Their tasks are the same: to help frame the issues and problems that receive attention; to formulate and implement projects, programs, and policies responsive to individual and group needs; and to work with and for various communities in allocating economic and physical resources most efficiently and most equitably.

Planners are often described as “generalists with a specialty.” The specialties offered at MIT include city design and development; housing, community, and economic development; international development; and environmental policy and planning, as well as cross-cutting opportunities to study urban information systems, regional planning, and transportation. These planning specialties can be distinguished by the geographic levels at which decision making takes place—neighborhood, city, regional, state, national, and global. Subspecialties have also been described in terms of the roles that planners are called upon to play, such as manager, designer, regulator, advocate, educator, evaluator, or futurist. The Department of Urban Studies and Planning is committed to educating planners who can advocate on behalf of underrepresented constituencies.

A focus on the development of practice-related skills is central to the department’s mission, particularly for students in the MCP professional degree program. Acquiring these skills and integrating them with classroom knowledge are advanced through the department’s field-based practicum subjects and research, and through internship programs. In fieldwork, students acquire competence by engaging in practice and then bringing field experiences back into the academic setting for reflection and discussion. Students may work with community organizations, government agencies, or private firms under the direction of faculty members involved in field-based projects with outside clients. In some cases, stipends may be available for fieldwork or internship programs.

During the month of January, the Department of Urban Studies and Planning offers a series of “mini-subjects” in specialized fields not covered by the regular curriculum, including both non-credit and for-credit offerings.

Specific opportunities for concentration and specialization available to students are detailed in the descriptions of the degree programs that follow.

UNDERGRADUATE STUDY

The Department of Urban Studies and Planning offers a Bachelor of Science in Planning, a HASS Minor in Urban Studies and Planning, a HASS Minor in International Development, a HASS Minor in Public Policy, and a variety of HASS concentrations. There is also an accelerated SB/MCP program which allows exceptional students to complete their undergraduate and master’s degree work in five years.

In addition, DUSP also hosts MIT’s Teacher Education Program (TEP), described in the section on Career and Professional Options in the Undergraduate Education chapter in Part 1. TEP provides an option for students interested in exploring new ideas in teaching and learning as applied to K–12 schools. Studies in TEP can also lead to licensure in math or science teaching at the high school or middle school levels.

Bachelor of Science in Planning/ Course 11

The Department of Urban Studies and Planning offers an interdisciplinary preprofessional undergraduate major designed to prepare students for careers in both the public and private sectors. The major also provides a foundation for students who are considering graduate work in law, public policy, international development, urban design, management, and planning. The subjects in the major teach students how the tools of economics, policy analysis, political science, and urban design can be used to solve social and environmental problems in the United States and abroad. In addition, students learn the skills and responsibilities of planners who seek to promote effective and equitable social change.

After satisfying the core requirements listed below, students use their electives to pursue a specific track. We suggest one of the following, but will accept self-designed options to better meet a student’s interest: urban and environmental policy and planning; urban society, history, and politics; or urban and regional public policy. The required laboratory emphasizes urban information systems and offers skills for measurement, representation, and analysis of urban phenomena. In the laboratory subject, students also explore the ways emerging technology can be used to improve government decision making.

Students are encouraged to develop a program that will strengthen their analytic skills, broaden their intellectual perspectives, and test these insights in real-world applications. Students must complete a senior project that synthesizes what they have learned. This project may consist of an analysis of a public policy issue, a report on a problem-solving experience
from an internship or other field experience, or a synthesis of research on urban affairs.

Five-Year SB-MCP Option
Undergraduate Course 11 majors may apply for admission to the department’s Master in City Planning (MCP) program in their junior year. Students accepted into the five-year program receive both the Bachelor of Science and the MCP at the end of five years. Admission is intended for those undergraduates who have demonstrated exceptional performance in the major and show commitment to the field of city planning. Criteria for admission include the following:

- A strong academic record in Course 11 subjects
- Letters of reference from departmental faculty
- Practical experience in planning, which could be gained through internships, practicums, studios, Undergraduate Research Opportunities Program experiences, summer jobs, etc.
- A mature and passionate interest for the field that warrants further study

Students can obtain more information on the five-year program from Sandra Welford, undergraduate administrator, Room 7-346A, 617-253-9403.

Minor in Urban Studies and Planning
The six-subject Minor in Urban Studies and Planning offers students the opportunity to explore issues in urban studies and planning in some depth. Students initially take two Tier I subjects that establish the political, economic, and design contexts for local, urban, and regional decision making. Next, students choose three Tier II elective subjects, which provide an opportunity to focus on urban and environmental policy issues or to study urban problems and institutions. Students may also choose from a variety of graduate courses, subject to the instructor’s permission. Finally, students take 11.123 Big Plans and Mega-Urban Landscapes, a subject that aims to synthesize past and present efforts to implement knowledge about large-scale projects and policies. Students are encouraged to craft a minor that reflects their own particular interests within the general parameters of the

Bachelor of Science in Planning/Course 11

<table>
<thead>
<tr>
<th>General Institute Requirements (GiRs)</th>
<th>Subjects</th>
<th>Units</th>
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<tbody>
<tr>
<td>Science Requirement</td>
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<tr>
<td>Humanities, Arts, and Social Sciences Requirement (four subjects can be satisfied by subjects in the Departmental Program)</td>
<td>6</td>
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<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>8</td>
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<tr>
<td>Laboratory Requirement (can be satisfied by 11.188 in the Departmental Program)</td>
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<tr>
<td>Total GIR Subjects Required for SB Degree</td>
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<tr>
<th>Communication Requirement</th>
<th>Subjects</th>
<th>Units</th>
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<tbody>
<tr>
<td>The program includes a Communication Requirement of 4 subjects: 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and 2 subjects designated as Communication Intensive in the Major (CI-M).</td>
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<tr>
<th>PLUS Departmental Program</th>
<th>Subjects</th>
<th>Units</th>
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<tbody>
<tr>
<td>Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics)</td>
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<table>
<thead>
<tr>
<th>Required Subjects</th>
<th>Units</th>
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<tr>
<td>11.001 Introduction to Urban Design and Development, 12, HASS-H</td>
<td>69</td>
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<tr>
<td>11.002 Making Public Policy, 12, HASS-S, CI-H</td>
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<tr>
<td>11.011 The Art and Science of Negotiation, 12, HASS-S</td>
<td></td>
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<tr>
<td>11.123 Big Plans and Mega-Urban Landscapes, 9, HASS-S</td>
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<tr>
<td>14.01 Principles of Microeconomics, 12, HASS-S</td>
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<tr>
<td>11.188 Urban Planning and Social Science Laboratory, 12, LAB, CI-M</td>
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<tr>
<th>Planned Electives</th>
<th>Subjects</th>
<th>Units</th>
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<tbody>
<tr>
<td>Course 11 majors are required to formulate or select one stream of coursework for concentration. They can select from the following recommended options or create their own stream tailored to a particular set of urban, policy, or planning concerns.</td>
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<tr>
<th>Environmental Policy</th>
<th>Subjects</th>
<th>Units</th>
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<tbody>
<tr>
<td>11.005 Methods of Policy Analysis, 12, HASS-S; 11.005: 14.01</td>
<td>57–60</td>
<td></td>
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<tr>
<td>11.016 The Once and Future City, 12, HASS-H, CI-H</td>
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<tr>
<td>11.021 Environmental Law, Policy, and Economics: Pollution Prevention and Control, 12, HASS-S</td>
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<tr>
<td>11.022 Regulation of Chemicals, Radiation, and Biotechnology, 12; permission of instructor</td>
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<tr>
<td>11.151 Energy Decisions, Markets, and Policies, 12, HASS-S; 14.01*</td>
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<tr>
<td>11.162 Politics of Energy and the Environment, 12, HASS-S</td>
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<tr>
<td>11.165 Energy and Infrastructure Technologies, 12, HASS-S; 14.01*</td>
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<tr>
<td>11.168 Enabling Energy Efficiency: Practice and Innovation, 12</td>
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<tr>
<th>Urban History and Society</th>
<th>Subjects</th>
<th>Units</th>
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<tbody>
<tr>
<td>11.012 The Ancient City, 12, HASS-H</td>
<td>57–60</td>
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<tr>
<td>11.013 American Urban History I, 9, HASS-H</td>
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<td>11.014 American Urban History II, 9, HASS-H</td>
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<tr>
<td>11.015 Riots, Strikes, and Conspiracies in American History, 12, HASS-HT, CI-H</td>
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<td>11.019 Migration and Immigration in US History, 12, HASS-S</td>
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<td>11.020 Downtown, 9, HASS-H</td>
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<tr>
<td>11.150 Metropolis: A Comparative History of New York City, 12, HASS-H</td>
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<td>11.152 The Ghetto: From Venice to Harlem, 12, HASS-S</td>
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<tr>
<th>International Development</th>
<th>Subjects</th>
<th>Units</th>
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<tbody>
<tr>
<td>11.005 Introduction to International Development, 12, HASS-S</td>
<td>57–60</td>
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<tr>
<td>11.023 D-Lab: Development, 12, HASS-S</td>
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<tr>
<td>11.140 Urbanization and Development, 12</td>
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<td>11.144 Project Appraisal in Developing Countries, 12</td>
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<tr>
<td>11.147 Urban Public Finance in Developing Countries, 12, HASS-S; permission of instructor</td>
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<tr>
<td>11.164 Human Rights in Theory and Practice, 12, HASS-S; permission of instructor</td>
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<tr>
<td>11.165 Energy and Infrastructure Technologies, 12, HASS-S; 14.01*</td>
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<tr>
<td>11.166 Law, Social Movements, and Public Policy, 12, HASS-S; permission of instructor</td>
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<thead>
<tr>
<th>Urban Field Experience</th>
<th>Subjects</th>
<th>Units</th>
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<tbody>
<tr>
<td>Declared majors are encouraged to take the optional urban field experience subject. 11.027 City to City: Comparing, Researching, and Writing about Cities (CI-M) is taught in the spring and includes a trip during spring break. This course may be taken multiple times, as the content differs each year, but may only be counted once as a planned elective.</td>
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SCHOOL OF ARCHITECTURE AND PLANNING

### Thesis

Majors are required to write a senior thesis or complete a senior project. The thesis/project writing process is accompanied by a required undergraduate thesis preparation seminar, which meets in the fall.

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Name</th>
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<tbody>
<tr>
<td>11.ThT</td>
<td>Thesis Research Design Seminar, 12, CI-M</td>
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<tr>
<td>11.Thu</td>
<td>Undergraduate Thesis Seminar and Thesis, 12; 11.ThT</td>
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### Departmental Program Units That Also Satisfy the GIRs

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Name</th>
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<tbody>
<tr>
<td>4.233</td>
<td>Choose four in consultation with the minor advisor:</td>
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<tr>
<td>4.234</td>
<td>The New Global Planning Practitioner</td>
</tr>
<tr>
<td>11.005</td>
<td>Introduction to International Development</td>
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<tr>
<td>11.025j</td>
<td>D-Lab: Development</td>
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<tr>
<td>11.140</td>
<td>Urbanization and Development</td>
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</table>

### Tier I

**Minor in International Development**

The new HASS Minor in International Development aims to increase students’ ability to understand, analyze, and tackle problems of global poverty and economic development in the developing world. Challenges include increasing urbanization; the need for industrial growth as well as jobs for an increasing number of educated youth; the crisis of resources and infrastructure; the fragmentation of state capacity and rising violence; ethical and moral issues raised by development planning; the role of appropriate technology and research; and popular discontent. The minor emphasizes problem-solving, multidisciplinarity, and an understanding of institutions at various levels—from the local to the global—as the keys to solving today’s problems in emerging countries.

The six-subject minor is structured into two tiers. The subjects in the first tier provide a general overview of the history of international development and major theories and debates in the field, and an introduction to the dilemmas of practice. They also introduce the challenges of applying models of interventions across contexts and the importance of understanding local institutional frameworks and political economies across scales and levels of governance.

### Tier II

- **Four subjects from the following:**
  - Introduction to International Development
  - The Art and Science of Negotiation
  - American Urban History I
  - American Urban History II
  - The Once and Future City
  - Environmental Law, Policy, and Economics: Pollution Prevention and Control

### Tier III

- **Big Plans and Mega-Urban Landscapes**
  - Choose four in consultation with the minor advisor:

Additional subjects not listed above may be included in the minor at the discretion of the minor advisor.

Further information can be obtained from Professor Balakrishnan Rajagopal, Room 9-432, 617-253-6315; braj@mit.edu.

## Minor in Public Policy

The interdisciplinary HASS Minor in Public Policy is intended to provide a single framework for students interested in the role of public policy in the field of their technical expertise. Because
the Course 11 major has a strong public policy element and several subjects are redundant, Course 11 majors are not eligible for the Minor in Public Policy. A detailed description and list of requirements for this minor can be found in the Interdisciplinary Undergraduate Programs and Minor section in Part 3.

HASS Concentrations
DUSP offers clusters of subjects that satisfy the Institute requirement. These three-subject clusters allow students either to develop competence within a specific discipline or to explore a particular policy problem. Possible areas of concentration include: designing the urban environment, environmental policy, urban history, policy analysis and urban problems, legal issues and social change, and education. Sample programs are available at [http://dusp.mit.edu/](http://dusp.mit.edu/).

The DUSP concentration focusing on education can also lead to Massachusetts licensure in teaching math and science at the middle and high school levels. This requires taking 11.129, 11.130, and 11.131 in addition to the core subjects 11.124 and 11.125. More information is available from Eric Klopfer, Room E15-301, 617-253-2025.

GRADUATE STUDY

The Department of Urban Studies and Planning offers graduate work leading to the Master in City Planning and the Doctor of Philosophy. In conjunction with the Center for Real Estate, the department also offers a Master of Science in Real Estate Development. These programs are open to students from a variety of backgrounds. Urban studies, city planning, architecture, urban design, environmental planning, political science, civil engineering, economics, sociology, geography, law, management, and public administration all offer suitable preparation. For further information concerning academic programs in the department, application for admission, and financial aid, contact Graduate Admissions, Room 7-346, 617-253-9403.

Master in City Planning

The principal professional degree in the planning field is the Master in City Planning (MCP). The Department of Urban Studies and Planning provides graduate education for men and women who will assume professional roles in public, private, and nonprofit agencies, firms, and international institutions, in the United States and abroad. The department seeks to provide MCP students with the skills and specialized knowledge needed to fill traditional as well as emerging planning roles. The MCP is accredited by the American Planning Association.

The two-year Master in City Planning Program emphasizes mastery of tools for effective practice and is therefore distinct from undergraduate liberal arts programs in urban affairs or doctoral programs that emphasize advanced research skills. MCP graduates work in a broad array of roles, from "traditional" city planning to economic, social, and environmental planning. In addition to its basic core requirements, the program offers four areas of specialization: city design and development; environmental policy and planning; housing, community, and economic development; and international development. MCP students, in their application to the department, select one of these areas of specialization and, when applicable, indicate interest in the department programs in Transportation Policy and Planning, Urban Information Systems, and Regional Planning.

Each student's plan of study in the MCP Program is set forth in a program statement developed jointly by the student and faculty advisor during the student's first term. Linked to career development goals, the program statement describes the purposes and goals of study, the proposed schedule of subjects, the manner in which competence in a specialization is developed, and an indication of a possible thesis topic.

Degree Requirements. Students are expected to take a minimum of 36 credit units each term (at least three subjects, though more frequently four), yielding at least 126 total units, in addition to the thesis.

A collection of subjects and requirements to be taken during the student's two years in the MCP program constitute a "core experience" viewed as central to the professional program. The core subjects and requirements include the following:

- An introductory subject in the chosen specialization area, taken in the first term of the first year
- At least one core practicum subject, selected from an approved list, during the two-year program
- A thesis preparation seminar in the area of specialization, taken during the second or third term of study

Students identified as having weaker writing skills are also encouraged to take a writing course.

All students are required to submit a thesis on a topic of their choice. The department encourages MCP students to avoid the traditional perception of the thesis as a "mini-dissertation," and to think instead of a client-oriented, professional document that bridges academic and professional concerns. While most of the thesis work occurs during the last term of the second year, students are urged to begin the process of defining a thesis topic early in the second year through their participation in a required thesis preparation seminar.

Students in the MCP Program are encouraged to integrate fieldwork and internships with academic coursework. The Department of Urban Studies and Planning provides a variety of individual and group field placements involving varying degrees of faculty participation and supervision. Academic credit is awarded for field experience, although some students choose instead to participate in the work-study financial aid program. The department also sponsors a variety of seminars in which students have an opportunity to reflect on their field experiences.

The City Design and Development (CDD) group is concerned with shaping the built and natural environment of cities and suburban territories. Graduates work in a variety of private, public, and nonprofit roles: as urban designers; planning and design consultants; municipal and regional planners; managers of public agencies; advocates of historic preservation, housing
and land use, and real estate development; and as planners of transportation systems. The group is closely associated with faculty and students in the Department of Architecture, the Center for Real Estate, and the Media Lab. Many subjects are cross-listed with these programs. The diverse educational offerings ensure that every student can develop unique competence and intellectual depth in the field. There are several areas of concentration in city design and development: urban design, for those who wish to be involved in shaping the physical form and logistical function of cities; landscape urbanism, for those who wish to work at the intersection of territorial urbanization and natural processes; land use and community planning, for those who wish to work as municipal planners or consultants; and urban development, for those who wish to manage development projects for private companies or public sector organizations.

The Center for Advanced Urbanism—jointly administered by faculty from the CDD group and the Urbanism group in the Department of Architecture—is a research-based institution dedicated to implementing new integrative models of design and development.

The Environmental Policy and Planning (EPP) group emphasizes the study of how society conserves and manages its natural resources and works to promote sustainable development. Areas of concern include the role of science in environmental policy making, climate change mitigation and adaptation, sustainable international development, adaptive ecosystem management, environmental justice, global environmental treaty making, environmental regulation, energy efficiency and renewable energy, the role of private corporations in environmental management, and the mediation of environmental disputes. Students investigate the interactions between built and natural systems; the effectiveness of different approaches to environmental planning and policymaking; techniques for describing, modeling, forecasting, and evaluating changes in environmental quality; approaches to environmental policy analysis; strategies for stakeholder involvement in environmental planning; and mechanisms for assessing the choices posed by the environmental impacts of new technology in local, state, national, and international contexts.

The Housing, Community, and Economic Development (HCED) group’s mission is to prepare professionals with the skills and knowledge to be responsible leaders of nonprofit, governmental, and private sector organizations engaged in building equitable and sustainable urban communities, and to advance knowledge of effective and innovative policies and practices to build such communities. This mission is pursued through teaching and research based on collaboration with local people and institutions to take action to improve their communities. The planning focus encompasses the design, location, organization, and financing of housing, economic, and community development programs and the capital and labor markets that impact such development at the local level. The group is concerned with understanding how public policy and private markets affect housing, economic development, and the local economy; employing techniques for assessing community needs, including housing, community services facilities, and sources of jobs; and developing and implementing programs, policies, and strategies that are directed at meeting these needs. HCED places a strong emphasis on practice and effective action at the state, local, and neighborhood levels and emphasizes that strategic analysis of the institutional context within which action occurs is central to such effectiveness.

The International Development Group (IDG) draws on the experiences of developing and newly industrializing countries throughout the world as the basis for advice about planning at the local, regional, national, and global levels. IDG provides students with an integrated view of the institutional, legal, historical, economic, technological, and sociopolitical factors that have shaped successful planning experiences and how they translate into action. Class content and faculty expertise include economic development at various scales; regional planning (including decentralization); finance and project evaluation; housing, human settlements, and infrastructure services (transportation, telecommunications, water, sewerage); institutions of economic growth; law and economic development; industrialization and industrial policies (including privatization); poverty-reducing and employment-increasing interventions including informal sector, nongovernment organizations, and small enterprises; comparative urban and metropolitan politics and policy; property rights, collective action, and common property issues (water, forestry, grazing, agriculture); human rights and development; conflict and social dynamics in cities; post-conflict development; and globalization and governance.

Urban Information Systems (UIS) is a cross-cutting group that connects faculty, staff, and students who are interested in the ways information and communication technologies impact urban planning. Research topics include building neighborhood information systems to facilitate public participation in planning; exploring the complex relationships underlying urban spatial structure, land use, transportation, and the environment; modeling urban futures and metropolitan growth scenarios; and experimenting with mobile computing, location-based services, and the community building, planning, and urban design implications of ubiquitous computing. Our Responsive City Initiative fosters interaction among students, faculty, and staff, and across research groups and projects. Through seminars and related activities, we share experiences and find ways to collaborate on the technical, planning, and social science aspects of making information technology—enabled urban futures more responsive to public and private interests in ways that are transparent and equitable.

Much of UIS’s work involves the development and use of planning-related software and the spatial analysis tools and systems (such as GIS and distributed geoprocessing) that are increasingly important parts of metropolitan information infrastructures. However, UIS interests go beyond the development and use of specific technologies and extend to an examination of the ripple effects of computing, communications, and digital spatial information on current planning practices and on the meaning and value of the impacted communities and planning institutions.

Simultaneous Master’s Degrees in City Planning and Architecture

Students who have been admitted to either the Department of Urban Studies and Planning or the Department of Architecture can propose a program of joint work in the two fields that will lead to the simultaneous awarding of two degrees. Degree combinations may be MCP/MArch or MCP/SMArchS. A student must apply by the
January deadline prior to beginning the last full year of graduate study for the first degree: MCP and SMArchS. SMArchS students must apply during their first year at MIT (by the end of the first term); MArch students must apply during or before their second year. Students are first approved by the Dual Degree Committee and then considered during the spring admissions process. All candidates for simultaneous degrees must meet the requirements of both degrees, but may submit a joint thesis.

Simultaneous Master’s Degrees in City Planning and Transportation
Students who have been admitted to study for the Master in City Planning or the Master of Science in Transportation may apply to the other program during their first year of study and propose a program of joint work in the two fields that will lead to the simultaneous awarding of two degrees. Details of this program are provided under Interdepartmental Programs in the Civil and Environmental Engineering section.

Simultaneous Master’s Degrees in City Planning and Real Estate Development
Students who have been admitted to the Master in City Planning Program or the Master of Science in Real Estate Development Program may apply to the other program during their first year of study and propose a program of joint work in the two fields that will lead to the simultaneous awarding of two degrees. Students may submit a joint thesis.

Master of Science in Urban Studies and Planning
Under special circumstances, admission may be granted to candidates seeking a one-year Master of Science (SM) degree. The SM is intended for professionals with a number of years of distinguished practice in city planning or related fields who have a clear idea of the courses they want to take at MIT, the thesis they want to write, and the DUSP faculty member with whom they wish to work. That faculty member must be prepared to advise the candidate when at MIT and to submit a letter of recommendation so indicating as part of the candidate’s application. This process means that prior to submitting an application the candidate must contact the appropriate DUSP faculty member to establish such a relationship. The SM does not require the candidate to take the core courses, which are mandatory for MCP candidates. As indicated above, a thesis is required. For further information concerning the SM option, contact Graduate Admissions, Room 7-346, 617-253-9403.

Urban Design Certificate
Students in the MCP, MArch, or SMArchS programs who complete a specific curriculum of subjects in history and theory, public policy, development, studios and workshops, and a thesis in the field of urban design are awarded a Certificate in Urban Design by the school. For further information contact the Joint Program in City Design and Development office, Room 10-485, 617-253-5115.

Environmental Planning Certificate
Students in the MCP and PhD program who complete a prescribed set of subjects are awarded a Certificate in Environmental Planning. For further information contact Nina Tamburello, EPP administrator, Room 9-330, 617-253-1509.

Doctor of Philosophy
The PhD is the advanced research degree in urban planning or urban studies. Admission requirements are substantially the same as for the master’s degree, but additional emphasis is placed on academic preparation, professional experience, and the fit between the student’s research interests and the department’s research activities. Nearly all successful applicants have previously completed a master’s degree.

The doctoral program emphasizes the development of research competence and flexibility in exploring critical planning questions. Students work under the mentorship of a faculty advisor. They may focus their studies on any subfield of planning in which the faculty have expertise. After successful completion of coursework, students are required to take oral and written qualifying general exams in two fields: an intellectual discipline (city design and development, international development economics, public policy, planning information systems, regional and urban economics, or urban sociology) and a field to which this discipline is applied and which coincides with the student’s research interest and possible dissertation topic. Doctoral candidates are expected to complete the qualifying general examinations before beginning their third year of residence. Upon completing the qualifying general examination, a PhD candidate must write and successfully defend a doctoral dissertation that gives evidence of the capacity to do independent and innovative research. A minimum of 72 units plus 36 units for the dissertation (a minimum of 108 units) is required for the PhD degree.

Interested and qualified students can undertake joint doctoral programs with the Department of Political Science, the Department of Economics, or the Department of Civil and Environmental Engineering.

Interdisciplinary Programs

Graduate Programs in Transportation
MIT provides a broad range of opportunities for transportation-related education. Courses and classes span the School of Engineering, the Sloan School of Management, and the School of Architecture and Planning, with many activities covering interdisciplinary topics that prepare students for future industry, government, or academic careers.

A variety of graduate degrees are available to students interested in transportation studies and research, including a Master of Science in Transportation and PhD in Transportation, described under Interdisciplinary Graduate Programs in Part 3.

Nondegree Programs
A limited number of nondegree students are admitted to the department each term. This special student status is especially designed for professionals interested in developing specialized skills, but is also available to others.

The Community Innovators Lab (CoLab) promotes social justice by expanding access to and engagement with the knowledge developed by people working on the ground in disenfranchised, low-income communities. CoLab aims to both empower and learn from those individuals who, in the face of injustice, inequality, and exclusion, have dedicated themselves to making their communities healthier and more vibrant places to live. The knowledge that is formed in the face of struggles to create lasting change, by those who are least served by society, is significant, sophisticated, and essential for
By focusing its efforts on helping community practitioners “know what they know,” CoLab has successfully supported resident-directed change in underserved communities across the United States since 1998. Today CoLab hosts a variety of projects and guides the community-based work of up to 20 fellows each year. CoLab advances the use of practitioner and community knowledge through three strategic pathways:

• **Identifying, documenting, and organizing** practitioner and community knowledge developed through on-the-ground social justice work.

• **Building opportunities and practical methods** for community practitioners to use to engage their peers and others they wish to influence with the knowledge arising from their community practice.

• **Analyzing and communicating** the value and merits of practitioner and community knowledge to broad audiences.

CoLab is located in Room 7-307. Further information can be found on the CoLab website at [http://colab.mit.edu/](http://colab.mit.edu/).

The **Special Program for Urban and Regional Studies** (SPURS) provides an opportunity for a small number of highly qualified mid-career professionals from developing countries. Fellows spend a year at MIT studying the problems of regional and urban change in the broad context of international development. SPURS is an intentionally flexible program, offering the option of a nondegree or an MS degree program. For further information contact Nimfa de Leon, Room 9-435, 617-253-5915 or visit [http://web.mit.edu/spurs/www/](http://web.mit.edu/spurs/www/).

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**FACULTY AND STAFF**

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Department Head

**Professors**

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Professor of Urban Studies and History

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Director of Research, Center for Real Estate

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Chair, PhD Committee

Xavier de Souza Briggs, PhD  
Associate Professor of Community Development and Public Policy

Annette Kim, PhD  
Associate Professor of Urban and Regional Planning  
Chair, Undergraduate Committee

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Director, Teacher Education Program

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Ford Professor of Urban Affairs, Emeritus

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Tunney F. Lee, BArch  
Professor of Architecture and Urban Studies and Planning, Emeritus

Frank Levy, PhD  
Daniel Rose Professor of Urban Economics, Emeritus
The School of Engineering aims to educate and prepare men and women for leadership in industry, government, and educational institutions; to advance the knowledge base of the engineering professions; and to influence the future directions of engineering education and practice.

The School’s educational programs emphasize the understanding of fundamental principles; facility with experimental, computational, and analytical methods; and versatility of mind that prepare the individual for a lifetime of learning and professional growth.
Technology’s enormous influence on society has created a large demand for engineering graduates in the professional practice of engineering and beyond. An engineering education from MIT provides students with exceptional opportunities to define and impact the future of their fields, as well as related ones such as medicine, management, law, and government. Never have the challenges and opportunities of engineering been more exciting or more critical to the long-term well-being of society than they are today.

In a world increasingly influenced by scientific and technological innovation, engineers provide important leadership to society. By creating, developing, and managing complex technologies and products, they play a crucial role in contributing to the betterment of humanity and in shaping our world. Seeking solutions to the most difficult challenges of our day in the context of physical, economic, human, political, legal, and cultural realities makes engineering a tremendously rewarding endeavor.

The first-year curriculum for undergraduates includes physics, chemistry, mathematics, biology, and the humanities, arts, and social sciences. An undergraduate student normally becomes affiliated with a particular department at the beginning of sophomore year and works closely with an advisor from that department or program to shape their course of study. Students who would like to explore an engineering major are encouraged to seek out and get involved with one of the engineering departments during freshman year. Nearly every engineering department offers exciting subjects that introduce freshmen to engineering. Freshman Advising Seminars bring students together in small groups with engineering faculty. Undergraduate Research Opportunities Projects (UROPs) are a great way to delve into cutting-edge engineering research.

Once a student chooses an undergraduate major, there are many opportunities for individual initiatives. For example, the flexible engineering degree program offers students in select departments the opportunity to satisfy department-based core requirements and declare an additional concentration, which can be broad and interdisciplinary in nature (energy, transportation, or the environment), or focused on areas that can be applied to multiple fields (robotics and controls, computational engineering, or engineering management). Students may also elect to create their own concentrations under supervision from department faculty. In addition, many undergraduates combine their primary major with a second one in another area, such as management, political science, economics, one of the sciences, or another area of engineering. Others organize their programs so they can receive both undergraduate and graduate degrees simultaneously. A series of minor programs from across the Institute is also available.

Pioneering Programs in Engineering Education

Engineering education has been at the core of the Institute’s mission since its founding in 1861. MIT created the contemporary model of engineering education grounded in a dynamic, changing base of science. It pioneered the modern model of the research university, with externally sponsored research programs and a matrix of academic departments and research laboratories working across various disciplines. MIT also created entire new fields, for example, chemical engineering, sanitary engineering, naval architecture and marine engineering, and soil mechanics, and it also offered the first course in aeronautical engineering. More recently, the School of Engineering has responded with new degree programs that have made biology a foundational science for engineering, and it has created new avenues for students to pursue concentrations in broad, interdisciplinary areas such as energy, robotics, computational engineering, or poverty alleviation.

The School has distinguished itself as a leader in engineering education, where the teaching of applied, hands-on engineering is of the utmost importance. In 1916, it created one of the first industrial internship programs, now the David H. Koch School of Chemical Engineering Practice. Over the last several decades, the School of Engineering has launched numerous pioneering programs, many with industry, such as Leaders for Global Operations (1988), System Design and Management (1997), the Deshpande Center for Technological Innovation (2001), the Bernard M. Gordon–MIT Engineering Leadership Program (2008), and the MIT + K12 Video Project (2011).

The School of Engineering is constantly innovating in engineering education, developing novel pedagogical approaches, designing new subject offerings to strengthen current programs, and creating new disciplines, fields of study, majors, and graduate programs. Today, the School offers nearly 20 exciting engineering degree programs for its undergraduates. Two examples are the newly created interdepartmental degree offered by the Departments of Electrical Engineering and Computer Science and Biology, Course 6-7, that offers rigorous training in both molecular biology and computer science, an SB in Chemical-Biological Engineering—MIT’s first undergraduate engineering degree with modern molecular biology as its core science; and, since 2005–2006, the SB in Biological Engineering. A number of other new degree programs have launched in the past decade: the SB in Mechanical and Ocean Engineering, MEng in Manufacturing, SM in Computation for Design and Optimization, PhD in Computational and Systems Biology, PhD in Engineering Systems, and the SB in Engineering degree in either Mechanical Engineering or Aeronautics and Astronautics.

The School of Engineering also offers a range of co-curricular activities designed to enhance students’ academic and non-academic experiences at MIT. The Bernard M. Gordon–MIT Engineering Leadership Program seeks to train tomorrow’s engineering leaders through project-based learning, extensive interaction with industry leaders, hands-on product development, engineering leadership labs, and authentic leadership challenges and exercises. The Undergraduate Practice Opportunities Program (UPOP) is an innovative sophomore program that provides opportunities for students to learn first-hand about engineering practice outside the academic context through internships and intensive experiential-learning workshops that emphasize development of professional abilities and attitudes required in engineering work.

Because of its unique role in technological innovation, the School of Engineering is also the home of the Lemelson-MIT Program, an educational initiative that recognizes outstanding inventors as role models, encourages sustainable new solutions to real-world problems, and enables and inspires youth to pursue creative lives and careers through invention.

The School of Engineering is generally ranked at the top of its fields by third-party rankings and surveys. US News and World Report has placed the School at the top of its engineering rankings every year they have run their survey, as has the QS World University Rankings. The School’s eight
academic departments and one division are home to 370 faculty members, more than a third of the Institute’s total faculty. Among the most distinguished in the nation, nearly one third of the School’s current and emeritus faculty and research staff have been inducted into the National Academy of Engineering.

Almost 60 percent of MIT undergraduates with declared majors and more than 45 percent of all graduate students are in the School of Engineering.

**Interdepartmental Research Programs**
Within the School of Engineering, a student may develop a program that satisfies his or her own intellectual and professional objectives. A student interested in an interdepartmental program should study the department descriptions and Part 3, Interdisciplinary Programs, for opportunities that combine disciplines from MIT’s four other schools with those of the School of Engineering.

While the School’s academic departments provide continuity and stability for the basic engineering disciplines, they increasingly share interests in the way their individual disciplines are expressed and applied. Interdepartmental centers, laboratories, and programs provide opportunities for faculty, students, and research staff to undertake collaborative research and engage in educational programs dealing with these and other interdisciplinary applications of importance to society.

Interdisciplinary centers and laboratories in which School of Engineering faculty play leading roles include the following:

- Center for Advanced Nuclear Systems
- Center for Clean Water and Clean Energy
- Center for Computational Engineering
- Center for Ocean Engineering
- Center for Technology, Policy, and Industrial Development
- Center for Transportation and Logistics
- Computer Science and Artificial Intelligence Laboratory
- Deshpande Center for Technological Innovation
- Industrial Performance Center
- Institute for Medical Engineering and Science
- Koch Institute for Integrative Cancer Research
- Laboratory for Information and Decision Systems
- Laboratory for Manufacturing and Productivity
- Materials Processing Center
- Microsystems Technology Laboratories
- MIT Energy Initiative
- Singapore–MIT Alliance
- Transportation@MIT

School of Engineering faculty members also participate in the activities of other research centers and laboratories that are administered outside the School of Engineering. For more information, see the section on Interdisciplinary Research and Study in Part 3.

**Office of the Dean**
Ian Anton Waitz, PhD
Jerome C. Hunsaker Professor of Aeronautics and Astronautics
MacVicar Faculty Fellow
Dean

Cynthia Barnhart, PhD
Professor of Civil and Environmental Engineering and Engineering Systems
Director, Transportation@MIT
Associate Dean

Eileen Ng-Ghavidel, MBA
Assistant Dean for Finance and Human Resources

Donna R. Savicki, MA
Assistant Dean for Administration

Ralph Scala, MBA
Assistant Dean for Development

Chad Galts, MA
Director of Communications

Brian Tavares, BSBA
Senior Financial Officer

**School Professors**
Nicholas A. Ashford, JD, PhD
Professor of Technology and Policy

Timothy Berners-Lee
3Com Founders Professor of Engineering
Degrees Offered in the School of Engineering

**Aeronautics and Astronautics**  
**Course 16**
- SB: Aerospace Engineering
- SB: Aerospace Engineering with Information Technology
- SB: Engineering
- SM: Aeronautics and Astronautics
- SM/MBA: Engineering/Management—dual degree with Leaders for Global Operations Program
- PhD, ScD: Aeronautics and Astronautics
- PhD, ScD: Aerospace Computational Engineering
- PhD, ScD: Air-Breathing Propulsion
- PhD, ScD: Aircraft Systems Engineering
- PhD, ScD: Air Transportation Systems
- PhD, ScD: Autonomous Systems
- PhD, ScD: Communications and Networks
- PhD, ScD: Controls
- PhD, ScD: Humans in Aerospace
- PhD, ScD: Materials and Structures
- PhD, ScD: Space Propulsion
- PhD, ScD: Space Systems

**Biological Engineering**  
**Course 20**
- SB: Biological Engineering
- SM: Toxicology
- SM/MBA: Engineering/Management—dual degree with Leaders for Global Operations Program
- MEng: Biomedical Engineering
- PhD, ScD: Applied Biosciences
- PhD, ScD: Bioengineering
- PhD, ScD: Biological Engineering

**Chemical Engineering**  
**Course 10**
- SB: Chemical Engineering
- SB: Chemical-Biological Engineering
- SB: Engineering
- SM: Chemical Engineering
- SM: Chemical Engineering Practice
- SM/MBA: Engineering/Management—dual degree with Leaders for Global Operations Program
- PhD, ScD: Chemical Engineering
- PhD: Chemical Engineering Practice

**Civil and Environmental Engineering**  
**Course 1**
- SB: Civil Engineering
- SB: Environmental Engineering Science
- SM: Civil and Environmental Engineering
- SM/MBA: Engineering/Management—dual degree with Leaders for Global Operations Program
- MEng: Civil and Environmental Engineering
- MEng: Civil Engineering
- PhD: Civil Engineering
- PhD, ScD: Coastal Engineering
- PhD, ScD: Construction Engineering and Management
- PhD, ScD: Environmental Biology
- PhD, ScD: Environmental Chemistry
- PhD, ScD: Environmental Engineering
- PhD, ScD: Environmental Fluid Mechanics
- PhD, ScD: Geotechnical and Geoenvironmental Engineering
- PhD, ScD: Hydrology
- PhD, ScD: Information Technology
- PhD, ScD: Oceanographic Engineering (jointly with WHOI)
- PhD, ScD: Structures and Materials
- PhD, ScD: Transportation

**Computation for Design and Optimization**
- SM: Computation for Design and Optimization

**Computational and Systems Biology**  
**Course CSB**
- PhD: Computational and Systems Biology (jointly offered with the School of Science)

**Computer Science and Molecular Biology**  
**Course 6-7**
- SB: Computer Science and Molecular Biology (jointly offered with the School of Science)

**Electrical Engineering and Computer Science**  
**Course 6**
- SB: Computer Science and Engineering
- SB: Electrical Engineering and Computer Science
- SB: Electrical Science and Engineering
- SM: Electrical Engineering and Computer Science
- SM/MBA: Engineering/Management—dual degree with Leaders for Global Operations Program
- MEng: Electrical Engineering and Computer Science
- Electrical Engineer in Computer Science
- PhD, ScD: Computer Science
- PhD, ScD: Computer Science and Engineering
- PhD, ScD: Electrical Engineering
- PhD, ScD: Electrical Engineering and Computer Science

**Engineering Systems**  
**Course ESD**
- SM: Engineering and Management—jointly offered with the Sloan School of Management through the System Design and Management Program
- SM: Engineering Systems
- SM: Technology and Policy
- SM/MBA: Engineering/Management—dual degree with Leaders for Global Operations Program
- MEng: Logistics
- PhD: Engineering Systems
- PhD: Technology, Management, and Policy

**Harvard-MIT Division of Health Sciences and Technology**  
**Course HST**
- SM: Biomedical Informatics
- SM: Health Sciences and Technology
- MD: Medical Sciences (degree from Harvard Medical School)
- MEng: Biomedical Engineering
- ScD, PhD: Bioinformatics and Integrative Genomics
- ScD, PhD: Biomedical Engineering
- ScD, PhD: Electrical and Medical Engineering
- ScD, PhD: Health Sciences and Technology
- ScD, PhD: Mechanical and Medical Engineering
- ScD, PhD: Medical Engineering
- ScD, PhD: Medical Engineering and Bioastronautics
- ScD, PhD: Medical Physics
- ScD, PhD: Speech and Hearing Biosciences and Technology

Note: Many departments make it possible for a graduate student to pursue simultaneous master’s degrees.

**Materials Science and Engineering**  
**Course 3**
- SB: Archaeology and Materials
- SB: Materials Science and Engineering
- SM: Materials Science and Engineering
- Materials Engineer
- PhD, ScD: Archaeological Materials
- PhD, ScD: Materials Science and Engineering
## Mechanical Engineering  
### Course 2
- **SB**  Engineering
- **SB**  Mechanical and Ocean Engineering
- **SB**  Mechanical Engineering
- **SM**  Mechanical Engineering
- **SM**  Naval Architecture and Marine Engineering
- **SM**  Ocean Engineering
- **SM**/**MBA**  Oceanographic Engineering (jointly with WHOI)  Engineering/Management—dual degree with Leaders for Global Operations Program
- **MEng**  Manufacturing

### Mechanical Engineer
- **PhD, ScD**  Mechanical Engineering
- **PhD, ScD**  Naval Architecture and Marine Engineering
- **PhD, ScD**  Ocean Engineering
- **PhD, ScD**  Oceanographic Engineering (jointly with WHOI)

### Microbiology
- **PhD**  Microbiology

## Nuclear Science and Engineering  
### Course 22
- **SB**  Nuclear Science and Engineering
- **SM**  Nuclear Science and Engineering

### Nuclear Engineer
- **PhD, ScD**  Nuclear Science and Engineering

### Polymer Science and Technology
- **PhD**  Polymer Science and Technology

### Transportation
- **SM**  Transportation
- **PhD**  Transportation

## Notes
Many departments make it possible for a graduate student to pursue a simultaneous master’s degree. Several departments also offer undesignated degrees, which lead to the Bachelor of Science without departmental designation. The curricula for these programs offer students opportunities to pursue broader programs of study than can be accommodated within a four-year departmental program.

- **(1)** See Interdisciplinary Graduate Programs section in Part 3.
- **(2)** See Interdisciplinary Undergraduate Programs section in Part 3.
The students, faculty, and staff in the Department of Aeronautics and Astronautics (AeroAstro) share a passion for air and space vehicles, the technologies that enable them, and the missions they fulfill.

Aerospace is an intellectually challenging, economically important, and exciting field, offering unique opportunities for students and researchers to contribute to the future of exploration, transportation, communication, and security. The department’s mission is to prepare engineers for success and leadership in the conception, design, implementation, and operation of aerospace and related engineering systems. It achieves this through its commitment to educational excellence, and to the creation, development, and application of the technologies critical to aerospace vehicle and information engineering, and the architecture and engineering of complex high-performance systems.

The department has a tradition of both strong scholarship and of contributing to the solution of “industrial-strength” problems. Its reach within aerospace extends to high levels of policy and practice. The AeroAstro community includes a former space shuttle astronaut, a former secretary of the Air Force, two former NASA associate administrators, three former Air Force chief scientists, 12 members of the National Academy of Engineering, and 16 fellows of the American Institute of Aeronautics and Astronautics. Members of the department have served as executives in the aerospace industry and are the founders of aerospace and other companies.

Several years ago, working closely with its student, alumni, industry, government, and academic stakeholders around the world, AeroAstro developed and implemented a landmark educational initiative for its degree programs, known as CDIO. The CDIO initiative reflects the department’s belief that its graduates must be knowledgeable in all phases of the aerospace system life cycle: conceiving, designing, implementing, and operating. The department adopted a new form of undergraduate engineering education, motivating its students to master a deep working knowledge of the technical fundamentals while giving them the skills, knowledge, and attitudes necessary to lead in the creation and operation of products, processes, and systems. In addition, it reformed its teaching methods, redesigned its curriculum, and performed a $20 million state-of-the-art reconstruction of its teaching laboratories. AeroAstro’s academic program and facilities now serve as models for more than 30 engineering schools on four continents.

The reconstruction of the teaching laboratories was manifested in the creation of the Learning Laboratory for Complex Systems. The Learning Laboratory provides enhanced opportunities for hands-on learning experiences closely integrated with the department’s curriculum. The Learning Lab’s Arthur Gelb Laboratory features a modern machine shop, composites fabrication facility, electronics design lab, and large team projects area with equipment for student projects. The Robert C. Seamans Jr. Laboratory is a community study area with meeting and discussion rooms, an extensively IT-equipped design/conference room, and a comprehensive aerospace library. The Design Studio, which replicates facilities at major aerospace companies, provides IT and software resources to support concurrent team engineering sessions and distance learning. The Gerhard Neumann Hangar includes low-speed and supersonic wind tunnels, computers equipped with flight simulation applications, engineering hardware displays, and workspace for large-scale student projects.

AeroAstro students, faculty, and staff work with each other, with colleagues across MIT, and with institutions around the world. These linkages enable them to tackle challenging multidisciplinary problems and to amplify their contributions. As a result, the department is connected, busy, global, hectic, open, collegial, and fun. Faculty and students are engaged in hundreds of research projects under the auspices of the department’s laboratories and centers. Many research activities in other MIT laboratories and centers are open to AeroAstro students as well. See the Research Laboratories and Activities section below for more information.

Graduates with an aerospace engineering degree find careers in commercial and military aircraft and spacecraft engineering, space exploration, air- and space-based telecommunication industries, teaching, research, military service, and related technology-intensive fields such as transportation, information, and the environment. The comprehensive technical education, with its strong emphasis on understanding complex systems, is also excellent preparation for careers in business, law, medicine, and public service.

In looking toward future challenges and opportunities in the aerospace field, the department has identified eight areas in which it is committed to building and strengthening its ability to make important contributions: space exploration; autonomous systems; environment; communications and networks; computation, design, and simulation; air transportation; large-scale complex systems; and advancing engineering education. By striving for excellence in the underlying core disciplines and emphasizing the collaborative problem solving required for tackling the complex, multidisciplinary problems that characterize this industry, AeroAstro is positioning itself to respond to these and future opportunities and challenges.

Sectors of Instruction

The department’s faculty are organized into three sectors of instruction. Typically, a faculty member teaches both undergraduate and graduate subjects in one or more of the sectors.

Information Sector

Most of the aerospace systems of the future will either revolve around or critically depend upon information technology, and all will exploit IT to an increasing extent. The missions of many aerospace systems are fundamentally centered on gathering, processing, and transmitting information. Examples where information technology is central include communication satellites, surveillance and reconnaissance aircraft and satellites, planetary rovers, global positioning satellites, the air transportation system, and integrated defense systems. Other aerospace systems also must rely on information technology–intensive subsystems to provide important onboard functions, including fly-by-wire flight control, autonomous or semi-autonomous guidance and control, cooperative action (including flight in formations or swarms), and health monitoring systems. Furthermore, almost every aircraft or satellite is one system within a larger system. Information plays a central role in the interoperability of systems.

Faculty members in the Information Sector teach and perform research on a broad range of areas, including guidance, navigation, control, autonomy, communication, networks, and real-time mission-critical software and hardware. In many instances, the functions provided by aerospace information systems are critical to life
or mission success. The complex nature of an aerospace system can either be simplified by the use of information technologies or can become significantly more complicated through the misuse of information technologies. Hence, safety, fault-tolerance, verification, and validation are significant areas of inquiry. Ongoing research in this sector includes command and control of multiple unmanned/autonomous vehicles, space and airborne communication systems and networks, and software development methods for flight and mission-critical systems, investigation of air traffic management, and application of control to smart systems.

The Information Sector has strong linkages to the department’s Aerospace Systems Sector, particularly on issues related to how humans interact with aerospace vehicles. Other common interests include the safety aspects of large, mission-critical software systems, the design and operation of air transportation systems, and the design and operation of satellite systems. The sector also has linkages with the Vehicles Technology Sector. Current interests include research on unmanned aerial vehicles and smart structures. Moreover, the sector maintains linkages to the Electrical Engineering and Computer Science Department and the Engineering Systems Division through joint teaching and collaborative research in communication, networks, control, robotic systems, optimization, numerical techniques, and algorithms.

**Aerospace Systems Sector**

This sector is responsible for instruction and research in systems engineering, a discipline that denotes the methodologies used in the architecting, design, manufacture, and operation of the highly complex and demanding systems in the field of aeronautics and astronautics. The sector consists of faculty members with research specialties in this area, as well as faculty affiliates who contribute to the full disciplinary strength of the department.

The systems approach considers all factors important to the performance, economic viability, manufacture, acceptability, and operation of engineering systems—technical, social, environmental, production, financial, and safety aspects—and attempts to find optimal or best-value trade-offs among them while considering risk and uncertainty. The systems engineer must deal simultaneously with these factors, whether the objective is the transport of passengers in commercial aircraft, orbital communications, or the exploration of space, among others.

This sector addresses issues related to how humans interact with aerospace vehicles, including information-related and life-support aspects. Safety, fault-tolerance, verification, and validation are significant areas of inquiry. Ongoing research in the sector includes investigation of air traffic management, distributed satellite systems, enterprise architecture, integrated design of space-based optical systems, micro-gravity research into human physiology and technology maturation, and software development methods for flight and mission-critical systems.

Students interested in systems engineering should develop a strong background in some of the disciplines that support systems analysis, such as probability, statistics, optimization, operations research, manufacturing, and economics. Research labs associated with the activities of this sector include the Man Vehicle Laboratory, Space Systems Laboratory, Lean Advancement Initiative, International Center in Air Transportation, Operations Research Center, and Complex Systems Research Laboratory.

Many of the department faculty in this sector are also associated with the Engineering Systems Division.

**Vehicle Technologies Sector**

The faculty in this sector are responsible for teaching and research in the fields of computation, fluid mechanics, propulsion, materials, and structures—technologies needed for the design of aerospace vehicles. Although these can be considered disciplinary fields, the faculty emphasize interdisciplinary approaches in their teaching and research.

The intellectual breadth of the sector spans activities ranging from fundamental engineering science to design techniques, measurement technology, and detailed engineering of complex vehicle components and systems. Topics of interest include the computational design of fluid, material, and structural systems; heat transfer, aerodynamics, and fluid dynamics; reduced order modeling of unsteady fluid flows and structures; structural dynamic analysis and control; turbomachinery; robust design of propulsion and energy system components; electric and chemical space propulsion; gas turbine engine design; advanced composites, including nanoscale synthesis, characterization, and modeling; propulsion system integration; aerospace noise, emissions, and environmental impact; microelectromechanical systems and materials; multiscale modeling and simulation of advanced materials: engineered materials, failure mechanisms, and structural health monitoring; and biofluid mechanics.

Research laboratories and large interdisciplinary projects affiliated with the sector include the Aerospace Computational Design Laboratory; FAA/NASA Center of Excellence: Partnership for Air Transportation Noise and Emissions Reduction; Gas Turbine Laboratory; Nano-Engineered Composite Aerospace Structures Consortium; Space Propulsion Laboratory; and Technology Laboratory for Advanced Materials and Structures.

**UNDERGRADUATE STUDY**

Undergraduate study in the department leads to the Bachelor of Science in Aerospace Engineering (Course 16-1), the Bachelor of Science in Aerospace Engineering with Information Technology (Course 16-2), or the Bachelor of Science in Engineering (Course 16-ENG) at the end of four years.

**Bachelor of Science in Aerospace Engineering/Course 16-1 or Aerospace Engineering with Information Technology/Course 16-2**

This program is designed to prepare the graduate for an entry-level position in aerospace and related fields and for further education at the master’s level. The program includes an opportunity for a year’s study abroad.

The formal learning in the program builds a conceptual understanding in the foundational engineering sciences and professional subjects that span the topics critical to aerospace. This learning takes place within the engineering context of conceiving-designing-implementing-operating (CDIO) aerospace and related complex high-performance systems and products. The skills and attributes emphasized go beyond the formal classroom curriculum and include: modeling, design, the ability for self education, computer literacy, communication and teamwork skills, ethics, and— underlying all of these—appreciation for and understanding of interfaces and connectivity between various disciplines.
Opportunities for formal and practical (hands-on) learning in these areas are integrated into the departmental subjects through examples set by the faculty, subject content, and the ability for substantive engagement in the CDIO process in the department’s Learning Laboratory for Complex Systems.

The curriculum includes the General Institute Requirements described in the section on Undergraduate Education in Part 1 and the departmental program. The departmental program includes a fall-spring-fall sequence of subjects called Unified Engineering; subjects in dynamics, and principles of automatic control; a probability systems analysis subject and a subject in computers and engineering problem solving; professional area subjects; an experimental projects laboratory; and a capstone design subject. The program also includes the subject Differential Equations.

Unified Engineering is offered in sets of two 12-unit subjects in two successive terms. These subjects are taught cooperatively by several faculty members. Their purpose is to introduce new students to the disciplines and methodologies of aerospace engineering at a basic level, with a balanced exposure to analysis, empirical methods, and design. The areas covered include statics, materials, and structures; thermodynamics and propulsion; fluid mechanics; and signals and systems. Several laboratory experiments are performed and a number of systems problems tying the disciplines together and exemplifying the CDIO process are included.

Unified Engineering is usually taken in the sophomore year and the subjects Dynamics and Principles of Automatic Control in the first term of the junior year. Introduction to Computers and Engineering Problem Solving can be taken at any time, starting in the freshman year, but the fall term of the sophomore year is recommended.

The professional area subjects treat more completely and in greater depth the material to which the student is introduced in the core. In both degree programs, students take four subjects (48 units) from among the professional area subjects, with subjects in at least three areas. In Course 16-1, students must take at least two subjects designated as Aerospace Engineering. In Course 16-2, the student must take at least three subjects from among the Aerospace Information Technology list.

### Bachelor of Science in Aerospace Engineering/Course 16-1
Bachelor of Science in Aerospace Engineering with Information Technology/Course 16-2

<table>
<thead>
<tr>
<th>General Institute Requirements (GIRs)</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement [can be satisfied from among 1.00; 6.041; 18.03 or 18.034; and 16.001 in the Departmental Program]</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement [can be satisfied by 16.622, 16.821, or 16.831 in the Departmental Program]</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total GIR Subjects Required for SB Degree</td>
<td>17</td>
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</tr>
</tbody>
</table>

### Communication Requirement

The program includes a Communication Requirement of 4 subjects:
- 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and
- 2 subjects designated as Communication Intensive in the Major (CI-M). See the Laboratory and Capstone section below for specific options.

<table>
<thead>
<tr>
<th>PLUS Departmental Program</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics)</td>
<td></td>
<td>108</td>
</tr>
<tr>
<td><strong>Departmental Core (Required for students in both degree programs)</strong></td>
<td></td>
<td></td>
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<tr>
<td>16.001 Unified Engineering I, 12, REST; Physics II (GIR), 18.03*, Chemistry (GIR)</td>
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<tr>
<td>16.002 Unified Engineering II, 12; Physics II (GIR), 18.03*, Chemistry (GIR)</td>
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<tr>
<td>16.003 Unified Engineering III, 12; 16.001, 16.002</td>
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<tr>
<td>16.004 Unified Engineering IV, 12; 16.001, 16.002</td>
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<tr>
<td>1.00 Introduction to Computers and Engineering Problem Solving, 12, REST; Calculus I (GIR)</td>
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<td>16.06 Principles of Automatic Control, 12; 16.004</td>
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<td>16.07 Dynamics, 12; 16.004</td>
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<td>16.09 Statistics and Probability, 12; Calculus II (GIR)</td>
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<td>or</td>
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<tr>
<td>6.041 Probabilistic Systems Analysis, 12, REST; Calculus II (GIR)</td>
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<td>18.03 Differential Equations, 12, REST; Calculus II (GIR)</td>
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<td>or</td>
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<tr>
<td>18.034 Differential Equations, 12, REST; Calculus II (GIR)</td>
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<tr>
<td><strong>Professional Area Subjects</strong></td>
<td>at least 48</td>
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<tr>
<td>All students must take at least 48 units from among the subjects designated by the department as Professional Area Subjects. The program must include subjects from at least three professional areas. Students in Course 16-1 must take at least 24 units from the Professional Area Subjects in Aerospace Engineering. Students in Course 16-2 must take at least 36 units from among the Professional Area Subjects in Aerospace Information Technology.</td>
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<tr>
<td><strong>Aerospace Engineering, 16-1</strong></td>
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<tr>
<td>Fluid Mechanics</td>
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<td>16.100 Aerodynamics, 12; 16.004</td>
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<tr>
<td>Materials and Structures</td>
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<td>16.20 Structural Mechanics, 12; 16.004</td>
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<tr>
<td>Propulsion</td>
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<tr>
<td>16.50 Introduction to Propulsion Systems, 12; 16.004*</td>
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<tr>
<td>Computational Tools</td>
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<tr>
<td>16.90 Computational Methods in Aerospace Engineering, 12; 16.004*; 16.09*</td>
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<tr>
<td><strong>Aerospace Information Technology, 16-2</strong></td>
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<tr>
<td>Estimation and Control</td>
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<tr>
<td>16.30 Feedback Control Systems, 12; 16.06*</td>
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<tr>
<td>Computer Systems</td>
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<tr>
<td>6.221 Introductory Digital Systems Laboratory, 12, LAB; 16.004*</td>
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<tr>
<td>16.35 Real-Time Systems and Software, 12; 1.00*</td>
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<tr>
<td>Communications Systems</td>
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<tr>
<td>16.36 Communication Systems and Networks, 12; 16.004*, 16.09*</td>
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<td>Humans and Automation</td>
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<td>16.400 Human Factors Engineering, 12</td>
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<tr>
<td>16.410 Principles of Autonomy and Decision Making, 12; 1.00*</td>
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</tbody>
</table>
The subjects listed as Aerospace Engineering represent the advanced aerospace disciplines encompassing the design and construction of airframes and engines. This includes fluid mechanics, aerodynamics, heat and mass transfer, computational mechanics, flight vehicle aerodynamics, solid mechanics, structural design and analysis, the study of engineering materials, structural dynamics, and propulsion and energy conversion from both fluid/thermal (gas turbines and rockets) and electrical devices.

The subjects listed as Aerospace Information Technology are in the broad disciplinary area of information, which plays a dominant role in modern aerospace systems. This includes feedback, control, estimation, control of flight vehicles, software engineering, human factors engineering, aerospace communications and digital systems, the way in which humans interact with the vehicle through manual control and supervisory control of telerobotic processes (e.g., modern cockpit systems and human centered automation), and how planning and real-time decisions are made by machines.

Subjects in aerospace information technology are taught in both the departments of Aeronautics and Astronautics and Electrical Engineering and Computer Science.

The capstone subjects serve to integrate the various disciplines and emphasize the CDIO context of the AeroAstro curriculum. They also satisfy the Communication Requirement as Communication-Intensive in the Major (CI-M) subjects. The vehicle and system design subjects (16.82 and 16.83) require student teams to apply their undergraduate knowledge to the design of an aircraft or spacecraft system. One of these two subjects is required and is typically taken in the second term of the junior year or in the senior year. The rest of the capstone requirement is met by one of three 18-unit subjects or subject sequences: 16.621 and 16.622 Experimental Projects I and II; or 16.821 Flight Vehicle Development; or 16.831 Space Systems Development. These sequences satisfy the Institute Laboratory Requirement. In 16.821 and 16.831, students build and operate the vehicles or systems developed in 16.82 and 16.83. In 16.621/16.622, students conceive, design, and execute an original experimental research project in collaboration with a partner and a faculty advisor.

To take full advantage of the General Institute Requirements and required electives, the department recommends the following: 3.091 for the chemistry requirement; the biology requirement; a subject in economics (e.g., 14.01) as part of the HASS Requirement; and elective subjects such as 16.00 Introduction to Aerospace and Design, a mathematics subject (e.g., 18.06, 18.075, or 18.085), and additional professional area subjects in the departmental program. Please consult the department’s Academic Programs Office (Room 33-208) for other elective options.

**Bachelor of Science in Engineering/Course 16-ENG**

Course 16-ENG is an engineering degree program designed to offer flexibility within the context of aerospace engineering and is a complement to our aerospace engineering degree programs (16-1 and 16-2). The program leads to the Bachelor of Science in Engineering as recommended by the Department of Aeronautics and Astronautics. (The department will be seeking accreditation by the Accreditation Board of Engineering and Technology as an engineering degree.) Depending on their interests, Course 16-ENG students can develop a deeper level of understanding and skill in a field of engineering that is relevant to multiple disciplinary areas (e.g., robotics and control, computational engineering, mechanics, or engineering management), or a greater understanding and skill in an interdisciplinary area (e.g., energy, environment and sustainability, or transportation). This is accomplished first through a rigorous foundation within core aerospace engineering disciplines, followed by a six-subject concentration tailored to the student’s interests, and completed with hands-on aerospace engineering lab and capstone design subjects.

The core of our 16-ENG degree is very similar to the core of our 16-1 and 16-2 degrees, specifically including 16.001-16.004 Unified Engineering (described above), 18.03/18.034 Differential Equations, the programming subject 1.00 Introduction to Computers and Engineering Problem Solving, and either 16.06 Principles of Automatic Control or 16.07 Dynamics.

A significant part of the 16-ENG curriculum consists of electives (72 units) chosen by the student to provide in-depth study of a field of the student’s choosing. A wide variety of concentrations are possible in which well-selected academic subjects complement a foundation in aerospace engineering and General Institute...
Requirements. Potential concentrations include aerospace software engineering, autonomous systems, communications, embedded systems and networks, computational engineering, energy, engineering management, environment, space exploration and transportation. The AeroAstro faculty have developed specific recommendations in these areas; details are available from the AeroAstro Undergraduate Office and on the departmental website. However, concentrations are not limited to those listed above. Students can design and propose technically oriented concentrations that reflect their own needs and those of society.

The student’s overall program must contain a total of at least one and one-half years of engineering content (144 units) appropriate to his or her field of study. The required core, lab, and capstone subjects include 102 units of engineering topics. Thus, concentrations must include at least 42 more units of engineering topics. In addition, each concentration must include 12 units of mathematics or science.

The culmination of the 16-ENG degree program is our aerospace laboratory and capstone subject sequences. The capstone subjects serve to integrate the various disciplines and emphasize the CDIO context of our engineering curriculum. They also satisfy the Communication Requirement as CI-M subjects. The specific options available to students are identical to the 16-1 and 16-2 degree programs (see the description of those programs for additional details on the laboratory and capstone sequences).

**Double Major**

Students may pursue two majors under the Double Major Program outlined in the section on Undergraduate Education in Part 1. In particular, some students may wish to combine a professional education in aeronautics and astronautics with a liberal education that links the development and practice of science and engineering to their social, economic, historical, and cultural contexts. For them, the Department of Aeronautics and Astronautics and the Program in Science, Technology, and Society offer a double major program that combines majors in both fields. For a detailed description of that integrated degree program, refer to the description of the Program in Science, Technology, and Society in Part 2.

### Bachelor of Science in Engineering/Course 16-ENG

<table>
<thead>
<tr>
<th>General Institute Requirements (GiRs)</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>8</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>2</td>
</tr>
<tr>
<td>[can be satisfied from among 1.00; 18.03 or 18.034; and 16.001 in the Departmental Program]</td>
<td>1</td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>1</td>
</tr>
<tr>
<td>[can be satisfied by 16.621, 16.821, or 16.831/16.832 in the Departmental Program]</td>
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</tbody>
</table>

**Total GIR Subjects Required for SB Degree**

- 17

**Communication Requirement**

The program includes a Communication Requirement of 4 subjects:

- 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H);
- 2 subjects designated as Communication Intensive in the Major (CI-M). See the Laboratory and Capstone section below for specific options.

**PLUS Departmental Program**

*Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics)*

<table>
<thead>
<tr>
<th>Departmental Core (Required for students in both degree programs)</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.001 Unified Engineering I, 12, REST; Physics II (GIR), 18.03*; Chemistry (GIR)</td>
<td>84</td>
</tr>
<tr>
<td>16.002 Unified Engineering II, 12; Physics II (GIR); 18.03*, Chemistry (GIR)</td>
<td></td>
</tr>
<tr>
<td>16.005 Unified Engineering III, 12; 16.001, 16.002</td>
<td></td>
</tr>
<tr>
<td>16.004 Unified Engineering IV, 12; 16.001, 16.002</td>
<td></td>
</tr>
<tr>
<td>1.00 Introduction to Computers and Engineering Problem Solving, 12, REST; Calculus I (GIR)</td>
<td></td>
</tr>
<tr>
<td>18.03 Differential Equations, 12, REST; Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td>or 18.034 Differential Equations, 12, REST; Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td>16.06 Principles of Automatic Control, 12; 16.004</td>
<td></td>
</tr>
<tr>
<td>or 16.07 Dynamics, 12; 16.004</td>
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</tr>
</tbody>
</table>

**Concentration Subjects**

These electives define a concentrated area of study and must be chosen with the written approval of the AeroAstro Undergraduate Office. A minimum of 42 units of engineering topics and a minimum of 12 units of mathematics or science topics must be included in the 72 units of concentration electives. In all cases, the concentration subjects must be clearly related to the theme of the concentration.

**Laboratory and Capstone Subjects**

One of the following two subjects:

- 16.82 Flight Vehicle Engineering, 12, CI-M; permission of instructor
- 16.83j Space Systems Engineering, 12, CI-M; permission of instructor

Plus one of the following three sequences:

**Experimental Projects**

- 16.621 Experimental Projects I, 6; 16.06* or
- 16.622 Experimental Projects II, 12, LAB, CI-M; 16.621; 6.041

**Flight Vehicle Development**

- 16.821 Flight Vehicle Development, 18, LAB, CI-M; 16.82

**Space Systems Development**

- 16.83j Space Systems Development, 18, LAB, CI-M; permission of instructor

**Departmental Program Units That Also Satisfy the GIRs**

- (36)

**Unrestricted Electives**

- 48

**Total Units Beyond the GIRs Required for SB Degree**

- 198

*No subject can be counted both as part of the 17-subject GIRs and as part of the 198 units required beyond the GIRs. Exceptions are department subjects that satisfy the CI-M requirement. Every subject in the student’s departmental program will count toward one or the other, but not both.*

**Notes**

- Alternate prerequisites and corequisites are listed in the subject description.

For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, [http://student.mit.edu/catalog/index.cgi](http://student.mit.edu/catalog/index.cgi).
Undergraduate Opportunities
The following programs exist to broaden the opportunities available to undergraduate students.

Undergraduate Research Opportunities Program
To take full advantage of the unique research environment of MIT, undergraduates are encouraged to become involved in the research activities of the department through the Undergraduate Research Opportunities Program (UROP).
Many of the faculty actively seek undergraduates to become a part of their research teams. Specific areas of research opportunity are outlined in the section Research Laboratories and Activities below. For more information, contact Marie Stuppard in the AeroAstro Academic Programs Office, Room 33-202, 617-253-2279, mas@mit.edu.

Undergraduate Practice Opportunities Program
The Undergraduate Practice Opportunities Program (UROP) is a program sponsored by the School of Engineering and administered through the Office of the Dean of Engineering. Open to all School of Engineering sophomores, this program provides students an opportunity to develop engineering and business skills while working in industry, nonprofit organizations, or government agencies. UROP consists of three parts: an intensive one week engineering practice workshop offered during IAP, 10-12 weeks of summer employment, and a written report and oral presentation in the fall. Students are paid during their periods of residence at the participating companies and also receive academic credit in the program. There are no obligations on either side regarding further employment. For more information, contact Marie Stuppard in the AeroAstro Academic Programs Office, Room 33-202, 617-253-2279, mas@mit.edu.

Summer Internship Program
The Summer Internship Program provides undergraduates in the department the opportunity to apply the skills they are learning in the classroom in paid professional positions with employers throughout the United States. Students are offered individual career advising as well as seminars on resume writing, interviewing, and the job-search process. Some students may receive academic credit for their work experience by participating in a three-part educational process including preparation activity, the work experience, and reflection/evaluation activities when they return to school in the fall. For more information, contact Marie Stuppard in the AeroAstro Academic Programs Office, Room 35-329, 617-253-3725, mas@mit.edu.

Year Abroad Program
Through the MIT Global Education Office, students can apply to spend the junior year abroad. In particular, the department participates in the Cambridge University-MIT Undergraduate Exchange (CME) program. In any year-abroad experience, students enroll in the academic cycle of the host institution and take courses in the local language. They plan their course of study in advance; this includes securing credit commitments in exchange for satisfactory performance abroad. A grade average of B or better is normally required of participating AeroAstro students. For more information, contact Marie Stuppard (mas@mit.edu). Also refer to Undergraduate Education in Part 1 for detailed information on the CME program.

Massachusetts Space Grant Consortium
MIT leads the NASA-supported Massachusetts Space Grant Consortium (MASGC) in partnership with Amherst College, Boston University, Harvard University, College of the Holy Cross, Framingham State College, Holyoke Community College, Mount Holyoke College, Northeastern University, Olin College of Engineering, Roxbury Community College, Smith College, Tufts University, University of Massachusetts (Amherst and Dartmouth), Wellesley College, Williams College, Worcester State College, Worcester Polytechnic Institute, Boston Museum of Science, the Christa McAuliffe Center, the Clay Observatory, the Five College Astronomy Department, and many aerospace companies and laboratories throughout the United States. The program has the principal objective of stimulating and supporting student interest, especially that of women and underrepresented minorities, in space engineering and science at all educational levels, primarily through graduate. The program offers a number of activities to this end, including sponsorship of undergraduate research projects, support for student travel to present conference papers, a January internship at the Kennedy Space Center, a spring undergraduate seminar on modern space science and engineering, an annual public lecture by a distinguished member of the aerospace community, and summer workshops for precollege teachers. An important function of the program is coordinating placement of students in summer positions in industry and at NASA centers for summer academics and research opportunities. MASGC also participates in a number of public outreach and education policy initiatives in Massachusetts to increase public awareness and inform legislators about the importance of science, technology, engineering, and math education in the state. For more information, contact the program coordinator, Massachusetts Space Grant Consortium, Room 33-202, 617-258-5546, masgc@mit.edu.

Inquiries
For additional information concerning academic and research programs in the department, suggested four-year undergraduate programs, and interdisciplinary programs, contact the Department of Aeronautics and Astronautics Academic Programs Office, Room 33-208, 617-253-2279, mas@mit.edu.

GRADUATE STUDY
Graduate study in the Department of Aeronautics and Astronautics includes graduate-level subjects in Course 16 and others at MIT, and research work culminating in a thesis. Degrees are awarded at the master’s and doctoral levels. The range of subject matter is described in the section Sectors of Instruction; subjects are listed in the online MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi. The section Research Laboratories and Activities provides an overview of research interests. Detailed information may be obtained from the Department Academic Programs Office or from individual faculty members.

Entrance Requirements
In addition to the general requirements for admission to the Graduate School, applicants to the Department of Aeronautics and Astronautics should have a strong undergraduate background in the fundamentals of aerospace engineering and mathematics as described in the section Undergraduate Study. In some cases, unfulfilled
entrance requirements may also be satisfied during the first year of admission to the graduate program.

International students whose language of instruction has not been English in their primary and secondary schooling must pass the Test of English as a Foreign Language (TOEFL) with a minimum score of 100 out of 120, or the International English Language Testing System (IELTS) with a minimum score of 7 out of 9 to be considered for admission to this department. TOEFL waivers are not accepted. No other exams fulfill this requirement.

All applicants to the graduate program in Aeronautics and Astronautics also must submit the Graduate Record Examination (GRE) test results.

New graduate students are normally admitted as candidates for the degree of Master of Science. Admission to the doctoral program is offered to students who have been accepted for graduate study through a three-step process:

Passing performance on the field exam (FE). The standard for passing the FE is the demonstration of superior intellectual ability through skillful use of concepts, including synthesis of multiple concepts, in foundational, graduate-level material in a field of aerospace engineering.

Passing performance on the research evaluation (RE). The standard for passing the RE is the demonstration of a superior ability to solve research-oriented problems, with guidance, in a field relevant to aerospace engineering.

Granting of admission to the doctoral program through a faculty review consisting of an examination of the student’s achievements, including an assessment of the quality of past research work and evaluation of the student’s academic record in light of the performance on the FE and RE.

The FE and RE examination is offered once each year, during the January Independent Activities Period. Students who wish to be considered for the doctoral program must take the FE and RE before the fourth term following initial registration in the graduate program.

The Department of Aeronautics and Astronautics requires that all entering graduate students demonstrate satisfactory English writing ability by taking the Technical Writing Diagnostic Examination offered by the Program in Writing and Humanistic Studies. The examination is usually administered during the week after the initial date of registration in graduate school, and all entering candidates must take the examination at that time. Students with deficient skills must complete remedial training specifically designed to fulfill their individual needs. The remedial training prescribed by the Writing Program must be completed by the end of the first Independent Activities Period following initial registration in the graduate program or, in some cases, in the spring term of the first year of the program.

All incoming graduate students whose native language is not English are required to take the Department of Humanities English Evaluation Test (EET) offered at the start of each regular term. This test is a proficiency examination designed to indicate areas where deficiencies may still exist and recommend specific language subjects available at MIT.

**Degree Requirements**

All entering students are provided with additional information concerning degree requirements, including lists of recommended subjects, thesis advising, research and teaching assistantships, and course and thesis registration.

**Degrees Offered**

**Master of Science in Aeronautics and Astronautics**

The Master of Science (SM) degree is a one- to two-year graduate program with a beginning research or design experience represented by the SM thesis. This degree prepares the graduate for an advanced position in the aerospace field, and provides a solid foundation for future doctoral study.

The general requirements for the Master of Science degree are cited in the section on General Degree Requirements for graduate students in Part 1. The specific departmental requirements include at least 66 subject units, typically in graduate subjects relevant to the candidate’s area of technical interest. Of the 66 units, 42 units must be in H-level subjects, of which at least 21 units must be in departmental subjects. To be credited toward the degree, graduate subjects that are not H-level must carry a grade of B or better. In addition, a 24-unit thesis is required beyond the 66 units of coursework.

Full-time students normally must be in residence one full academic year. Special students admitted to the SM program in this department must enroll in and satisfactorily complete at least two graduate H-level subjects while in residence (i.e., after being admitted as a degree candidate) regardless of the number of subjects completed before admission to the program. Students holding research assistantships typically require a longer period of residence.

In addition, the department’s SM program requires one graduate-level mathematics subject. The requirement is satisfied only by graduate-level subjects on the list approved by the department graduate committee. The specific choice of math subjects is arranged individually by each student in consultation with their faculty advisor.

**Doctor of Philosophy and Doctor of Science**

AeroAstro offers doctoral degrees (PhD and ScD) that emphasize in-depth study, with a significant research project in a focused area. The admission process for the department’s doctoral program is described previously in this section under Entrance Requirements. The doctoral degree is awarded after completion of an individual course of study, submission and defense of a thesis proposal, and submission and defense of a thesis embodying an original research contribution.

The general requirements for this degree are given in the section on General Degree Requirements for graduate education in Part 1. A detailed description of the program requirements are outlined in a booklet titled The Doctoral Program, available on the department website. After successful admission to the doctoral program, the doctoral candidate selects a field of study and research in consultation with the thesis supervisor and forms a doctoral thesis committee, which assists in the formulation of the candidate’s research and study programs and monitors his or her progress. Demonstrated competence for original research at the forefront of aerospace engineering is the final and main criterion for granting the doctoral degree. The candidate’s thesis serves in part to demonstrate such competence and, upon completion, is defended orally in a presentation to the faculty of the department, who may then recommend that the degree be awarded.
Interdisciplinary Programs
The department participates in several interdisciplinary fields at the graduate level, which are of special importance for aeronautics and astronautics in both research and the curriculum.

Biomedical Engineering
This program is available to students interested in biomedical instrumentation and physiological control systems where the disciplines involved in aeronautics and astronautics are applied to biology and medicine. Graduate study combining aerospace engineering with biomedical engineering may be pursued through the Biomedical Engineering PhD program offered as part of the Medical Engineering and Medical Physics PhD program in the Harvard-MIT Division of Health Sciences and Technology (HST) or in conjunction with the PhD and MEng programs in the Department of Biological Engineering (BE). Students wishing to pursue a degree through HST or BE must apply to those graduate programs. At the master’s degree level, students in the department may specialize in biomedical engineering research, emphasizing space life sciences and life support, instrumentation and control, or in human factors engineering and in instrumentation and statistics. Most biomedical engineering research in the Department of Aeronautics and Astronautics is conducted in the Man Vehicle Laboratory.

Computation for Design and Optimization
The Computation for Design and Optimization (CDO) program offers a master’s degree to students interested in the analysis and application of computational approaches to designing and operating engineered systems. The curriculum is designed with a common core serving all engineering disciplines and an elective component focusing on specific applications. Current MIT graduate students may pursue a CDO master’s degree in conjunction with a department-based master’s or PhD program. For more information, see the full program description under Interdisciplinary Graduate Programs in Part 3, or visit http://computationalengineering.mit.edu/education/.

Flight Transportation
For students interested in a career in flight transportation, a program is available that incorporates a broader graduate education in disciplines such as economics, management, and operations research than is normally pursued by candidates for degrees in engineering. Graduate research emphasizes one of the four areas of flight transportation: airport planning and design; air traffic control; air transportation systems analysis; and airline economics and management, with subjects selected appropriately from those available in the departments of Aeronautics and Astronautics, Civil and Environmental Engineering, Economics, and the Interdepartmental Master of Science in Transportation (MST) program. Doctoral students may pursue a PhD with specialization in air transportation in the Department of Aeronautics and Astronautics or in the Interdepartmental PhD program in transportation or in the PhD program of the Operations Research Center (see the section on Graduate Programs in Operations Research in Part 3).

Leaders for Global Operations
The 24-month Leaders for Global Operations (LGO) program combines graduate education in engineering and management for those with two or more years of full-time work experience who aspire to leadership positions in manufacturing or operations companies. A required six-month internship comprising a research project at one of LGO’s partner companies leads to a dual-degree thesis, culminating in two master’s degrees—an MBA (or SM in management) and an SM from Aeronautics and Astronautics. The program is offered jointly through the MIT Sloan School of Management and the School of Engineering. For more information, visit http://lgo.mit.edu/ or see the program description under Engineering Systems Division.

System Design and Management
The System Design and Management (SDM) program is a partnership among industry, government, and the university for educating technically grounded leaders of 21st-century enterprises. Jointly sponsored by the School of Engineering and the Sloan School of Management, it is MIT’s first degree program to be offered with a distance learning option in addition to a full-time in-residence option. For more information, see the program description under Engineering Systems Division or visit http://sdm.mit.edu/.

Technology and Policy
The Master of Science in Technology and Policy is an engineering research degree with a strong focus on the role of technology in policy analysis and formulation. The Technology and Policy Program (TPP) curriculum provides a solid grounding in technology and policy by combining advanced subjects in the student’s chosen technical field with courses in economics, politics, and law. Many students combine TPP’s curriculum with complementary subjects to obtain dual degrees in TPP and either a specialized branch of engineering or an applied social science such as political science or urban studies and planning. For additional information, see the program description under Engineering Systems Division or visit http://web.mit.edu/tpp/.

Fellowships, Research and Teaching Assistantships
Financial assistance for graduate study may be in the form of fellowships or research or teaching assistantships. Both fellowship students and research assistants work with a faculty supervisor on a specific research assignment of interest, which generally leads to a thesis. Teaching assistants are appointed to work on specific subjects of instruction.

A special relationship exists between the department and the Charles Stark Draper Laboratory. This relationship affords fellowship opportunities for SM and PhD candidates who perform their research as an integral part of ongoing projects at the Draper Laboratory. Faculty from the department maintain close working relationships with researchers at Draper, and thesis research at Draper performed by Draper fellows can be structured to fulfill MIT residency requirements. Further information on the Draper Laboratory can be found in the section on Interdisciplinary Research and Study in Part 3.

Inquiries
For additional information concerning admissions, financial aid and assistantships, and academic, research, and interdisciplinary programs in the department, contact Beth Marois, bethamar@mit.edu.
The department’s faculty, staff, and students are engaged in a wide variety of research projects. Graduate students participate in all the research projects. Projects are also open to undergraduates through the Undergraduate Research Opportunities Program (UROP). Some projects are carried out in an unstructured environment by individual professors working with a few students. Most projects are found within the departmental laboratories and centers listed below. Faculty also undertake research in the Computer Science and Artificial Intelligence Laboratory, Draper Laboratory, Laboratory for Information and Decisions Systems, Lincoln Laboratory, Operations Research Center, Research Laboratory of Electronics, and the Program in Science, Technology, and Society, as well as in interdisciplinary laboratories and centers listed in the introduction to the School of Engineering. Refer to the section on Interdisciplinary Research and Study in Part 3 for more detailed descriptions.

Aerospace Computational Design Laboratory
The mission of the Aerospace Computational Design Laboratory (ACDL) is to improve the design of aerospace systems through the advancement of computational methods and tools which incorporate multidisciplinary analysis and optimization, probabilistic and robust design techniques, and next-generation computational fluid dynamics. The laboratory studies a broad range of topics which focus on the design of aircraft and aircraft engines. For more information, visit http://acdl.mit.edu/.

Aerospace Controls Laboratory
The Aerospace Controls Laboratory (ACL) investigates topics related to autonomous systems and control design for aircraft, spacecraft, and ground vehicles. Theoretical research is pursued in areas such as decision making under uncertainty; path planning, activity, and task assignment; estimation and navigation; sensor network design; and robust control, adaptive control, and model predictive control. A key part of ACL is RAVEN (Real-time Indoor Autonomous Vehicle Test Environment), a unique experimental facility that uses motion-capture sensing to enable rapid prototyping of flight controllers for helicopters and aircraft; robust coordination algorithms for multiple helicopters; and vision-based sensing algorithms for indoor flight.

Complex Systems Research Lab
Increasing complexity and coupling as well as the introduction of new digital technology are introducing new challenges for engineering, operations, and sustainment. We are designing system modeling, analysis, and visualization theory and tools to assist in the design and operation of safer systems with greater capability. To accomplish these goals, we apply a system’s approach to engineering that includes building technical foundations and knowledge and integrating these with the organizational, political and cultural aspects of system construction and operation. For more information, visit http://aeroastro.mit.edu/faculty-research/research-labs#csr.

While our main emphasis is aerospace systems and applications, our research results are applicable to complex systems in such domains as transportation, energy, and health. Current research projects include accident modeling and design for safety; model-based system and software engineering; reusable, component-based system architectures; interactive visualization; human-centered system design; system sustainment; and organizational factors in engineering and project management.

Gas Turbine Laboratory
The MIT Gas Turbine Laboratory has had a worldwide reputation for research and teaching at the forefront of gas turbine technology for more than 60 years. GTL’s mission is to advance the state of the art in fluid machinery for power and propulsion. The research is focused on advanced propulsion systems, energy conversion, and power, with activities in computational, theoretical, and experimental study of: loss mechanisms and unsteady flows in fluid machinery; dynamic behavior and stability of compression systems; instrumentation and diagnostics; advanced centrifugal compressors and pumps for energy conversion; gas turbine engine and fluid machinery noise reduction and aero-acoustics; and novel aircraft and propulsion system concepts for reduced environmental impact.

Examples of current and past research projects include: engine diagnostics and smart engines, aerodynamically induced compressor rotor whirl, a criterion for axial compressor hub-corner separation, axial and centrifugal compressor stability prediction, losses in centrifugal pumps, loss generation mechanisms in axial turbomachinery, the Silent Aircraft Initiative (a collaborative project with Cambridge University, Boeing, Rolls Royce, and other industrial partners), hybrid-wing-body airframe design and propulsion system integration for reduced environmental impact (NASA N+2), counter-rotating propfan aerodynamics and acoustics, an engine air-brake for quiet aircraft, inlet distortion noise prediction for embedded propulsion systems, novel aircraft concepts for 2035 (NASA N+3), high-speed micro gas bearings for MEMS turbomachinery, small gas turbines and energy concepts for portable power, and carbon-nanotube bearings. For more information, visit http://aeroastro.mit.edu/faculty-research/research-labs#gtl.

Humans and Automation Laboratory
The Humans and Automation Laboratory (HAL) focuses on the multifaceted interactions of human and computer decision making in complex sociotechnical systems. With the explosion of automated technology, the need for humans as supervisors of complex automatic control systems has replaced the need for humans in direct manual control.

A consequence of complex, highly automated domains in which the human decision maker is more “on-the-loop” than “in-the-loop” is that the level of required cognition has moved from that of well-rehearsed skill execution and rule following to higher, more abstract levels of knowledge synthesis, judgment, and reasoning.

Employing human-centered design principles to human supervisory control problems, and identifying ways in which humans and computers can leverage the strengths of the other to achieve superior decisions together is the central focus of HAL. Current research projects include collaborative human-computer decision making for command and control domains, investigating human understanding of multivariable optimization algorithms and visualization of cost/objective functions; the need for bounded collaboration, human supervisory control of
multiple heterogeneous unmanned vehicles; and developing and applying metrics for human supervisory systems. For more information, visit http://aeroastro.mit.edu/faculty-research/research-labs#hal.

International Center for Air Transportation
The mission of ICAT is to contribute to improving the safety, efficiency, environmental performance, and effectiveness of air transportation worldwide by education and the use of information technologies. Current areas of research interest include: advanced Air Traffic Control and Management (ATM, ATC) systems; satellite based Communication, Navigation, and Surveillance (CNS) systems in mature and developing world regions; advanced flight information systems; airline management; and operations (both flight operations and operations research). ICAT works closely with the Partnership for Air Transportation Noise and Emissions Reduction, and the MIT Transportation Initiative. For more information, visit http://aeroastro.mit.edu/faculty-research/research-labs#icat.

Lean Advancement Initiative
The Lean Advancement Initiative (LAI) at MIT, together with its international Educational Network, is a unique and powerful research consortium that provides a forum for sharing research findings, lessons learned, and best practices related to enterprise transformation. LAI engages its industry, government, and academic members in developing and institutionalizing principles, processes, behaviors, and tools for enterprise excellence. LAI’s work enables enterprises to effectively, efficiently, and reliably create value in complex and rapidly changing environments. For more information about LAI, see Interdisciplinary Research and Study in Part 3.

Man Vehicle Laboratory
The laboratory’s goal is to optimize human-vehicle system effectiveness by improving our understanding of human physiological and cognitive capabilities with particular emphasis on human spaceflight. Research is interdisciplinary, utilizing techniques from manual and supervisory control, estimation, signal processing, robotics, biomechanics, cognitive psychology, artificial intelligence, sensory-motor physiology, human factors, and biostatistics. The laboratory has several experiments in development for the International Space Station, and other ground-based projects sponsored by NASA and the National Space Biomedical Institute. Research focuses on control of posture and locomotion in partial gravity, spatial orientation in both real and virtual environments, aircraft cockpit displays and controls, and physiological and human factors aspects of EVA and artificial gravity systems, and design of exploration class missions. For more information, visit http://mvl.mit.edu/.

Partnership for Air Transportation Noise and Emissions Reduction
The Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) is a leading aviation cooperative research organization headquartered in the Aeronautics and Astronautics Department. An FAA Center for Excellence, PARTNER is sponsored by the FAA, NASA, Transport Canada, the US Department of Defense, and the US Environmental Protection Agency. PARTNER research fosters breakthrough technological, operational, policy, and workforce advances for the betterment of mobility, economy, national security, and the environment. PARTNER combines the talents of nine universities, three federal agencies, and more than 50 advisory board members, the latter spanning a range of interests from local government, to industry, to citizens’ community groups.

In addition to managing PARTNER, AeroAstro is active in PARTNER research such as performing scientific assessments of climate, air quality, and noise impacts; analysis of the life-cycle impacts of alternative fuels for aircraft; studies of aircraft particulate matter microphysics and chemistry; and studies of aircraft, airport, and airspace operational changes.

AeroAstro’s most prominent role within PARTNER is developing research tools that provide rigorous guidance to policy-makers who must decide among alternatives to address aviation’s environmental impact. The MIT researchers collaborate with an international team in developing aircraft-level and aviation system—level tools to assess the costs and benefits of different policies and R&D investment strategies. For more information, visit http://aeroastro.mit.edu/faculty-research/research-labs#partner.

Space Systems Laboratory
The Space Systems Laboratory’s (SSL) mission is to develop the technology and systems analysis associated with small spacecraft, precision optical systems, and International Space Station technology research and development. The laboratory encompasses expertise in structural dynamics, control, thermal, space power, propulsion, software development, and systems. Major activities include the development of small spacecraft thruster systems and the examination of issues associated with the distribution of function among satellites. In addition, technology is being developed for spaceflight validation in support of a new class of space-based telescope which exploits the physics of interferometry to achieve dramatic breakthroughs in angular resolution. The objective of the laboratory is to explore innovative concepts for the integration of future space systems and to train a generation of researchers and engineers conversant in this field. For more information, visit http://aeroastro.mit.edu/faculty-research/research-labs#ssl.

Technology Laboratory for Advanced Materials and Structures
The Technology Laboratory for Advanced Materials and Structures (TELAMS), formerly known as TELAC, has provided leadership in advancing the knowledge and capabilities of the composites and structures community through education of students, original research, and interaction with the community at large. The laboratory’s emphasis on composite materials has led to research topics ranging from a basic understanding of composite materials to their behavior in specific structural configurations, with the ultimate objective of gaining a sufficient understanding of their properties and how those properties interact to determine the behavior of laminates and structures. This includes multiscale modeling and simulation of the mechanics of advanced materials used in the aerospace industry. For more information, visit http://web.mit.edu/TELAMS/.

Wright Brothers Wind Tunnel
The largest on the MIT campus, this wind tunnel has a 7x10-foot cross-section, and is capable of steady flow speeds up to 200 mph. The facility is used for graduate and undergraduate instruc-
tion and research, as well as testing for outside companies. Active research and educational programs include aerodynamics of airplanes and space vehicles and the simulation of wind loads on architectural structures. Recently, the tunnel has been involved in aerodynamic test programs for Olympic athletes and sporting equipment such as bicycles and skis. For more information, visit [http://aeroastro.mit.edu/faculty-research/research-labs#wbwt](http://aeroastro.mit.edu/faculty-research/research-labs#wbwt).

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The mission of the Department of Biological Engineering (BE) is to educate next-generation leaders and to generate and translate new knowledge in a new bioscience-based engineering discipline fusing engineering analysis and synthesis approaches with modern molecular-genomic biology. Combining quantitative, physical, and integrative principles with advances in mechanistic molecular and cellular biology, biomedical engineering increases understanding of how biological systems function as both physical and chemical mechanisms; how they respond when perturbed by factors such as medical therapeutics, environmental agents, and genetic variation; and how to manipulate and construct them toward beneficial use. Through this understanding, new technologies can be created to improve human health in a variety of medical applications, and biology-based paradigms can be generated to address many of the diverse challenges facing society across a broad spectrum, including energy, the environment, nutrition, and manufacturing.

The department’s premise is that the science of biology is as important to the development of technology and society in the 21st century as physics and chemistry were in the 20th century, and that an increasing ability to measure, model, and manipulate properties of biological systems at the molecular, cellular, and multicellular levels will continue to shape this development. A new generation of engineers and scientists is learning to address problems through their ability to measure, model, and rationally manipulate the technological and environmental factors affecting biological systems. They are applying not only engineering principles to the analytical understanding of how biological systems operate, especially when impacted by genetic, chemical, physical, infectious, or other interventions; but also a synthetic design perspective to creating biology-based technologies for medical diagnostics, therapeutics, and prosthetics, as well as for applications in diverse industries beyond human health care.

UNDERGRADUATE STUDY

Bachelor of Science in Biological Engineering

The Department of Biological Engineering offers an undergraduate curriculum emphasizing quantitative, engineering-based analysis, design, and synthesis in the study of modern biology from the molecular to the systems level. Completion of the curriculum leads to the Bachelor of Science in Biological Engineering and prepares students for careers in diverse fields ranging from the pharmaceutical and biotechnology industries to materials, devices, ecology, and public health. Graduates of the program will be prepared to enter positions in basic research or project-oriented product development, as well as graduate school or further professional study.

The required core curriculum includes a strong foundation in biological and biochemical sciences, which are integrated with quantitative analysis and engineering principles throughout the entire core. Students who wish to pursue the Bachelor of Science in Biological Engineering are encouraged to complete the Biology General Institute Requirement during freshman year and may delay completion of Physics II until the fall term of sophomore year if necessary. The optional subject Introduction to Biological Engineering Design, offered during the spring term of freshman year, provides a framework for understanding the Biological Engineering SB program.

Students are encouraged to take the sophomore fall-term subject 20.110 Thermodynamics of Biomolecular Systems. This subject also fulfills an SB degree requirement in Biology. Alternatively, sophomores, or freshmen with advanced standing may take the spring-term 20.111 Physical Chemistry of Biomolecular Systems. Students are also encouraged to take Organic Chemistry I and Differential Equations during their sophomore year in order to prepare for the introductory biological engineering laboratory subject 20.109 that provides context for the lecture subjects and a strong foundation for subsequent undergraduate research in biological engineering through Undergraduate Research Opportunities Program projects or summer internships.

The advanced subjects required in the junior and senior years introduce additional engineering skills through lecture and laboratory subjects and culminate in a senior design project. These advanced subjects maintain the theme of molecular to systems-level analysis, design, and synthesis based on a strong integration with biology fundamentals. They also include a variety of restricted electives that allow students to develop expertise in one of six thematic areas: systems biology, synthetic biology, biophysics, pharmacology/toxicology, cell and tissue engineering, and microbial systems. Many of these advanced subjects are jointly taught with other departments in the School of Engineering or School of Science and may fulfill degree requirements in other programs.

Minor in Biomedical Engineering

An interdepartmental Minor in Biomedical Engineering is available to all undergraduate students outside the BE (Course 20) major. See Interdisciplinary Undergraduate Programs and Minors in Part 3 for detailed information.

Minor in Toxicology and Environmental Health

The Department of Biological Engineering offers an undergraduate Minor in Toxicology and Environmental Health. The goal of this program is to meet the growing demand for undergraduates to acquire the intellectual tools needed to understand and assess the impact of new products and processes on human health, and to provide a perspective on the risks of human exposure to synthetic and natural chemicals, physical agents, and microorganisms.

Given the importance of environmental education at MIT, the program is designed to be accessible to any MIT undergraduate. The program consists of three required didactic core subjects and one laboratory subject, as well as one restricted elective. The prerequisites for the core subjects are 5.111/5.112 Principles of Chemical Science or 3.091 Introduction to Solid State Chemistry plus 7.012/7.013/7.014 Introductory Biology.
Bachelor of Science in Biological Engineering/Course 20

General Institute Requirements (GIRs) Subjects
Science Requirement 6
Humanities, Arts, and Social Sciences Requirement 8
Restricted Electives in Science and Technology (REST) Requirement [can be satisfied by 5.12 and 18.03 in the Course 20 Program] 2
Laboratory Requirement [can be satisfied by 20.109] 1
Total GIR Subjects Required for SB Degree 17

Communication Requirement
The program includes a Communication Requirement of 4 subjects:
2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and
2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Course 20 Program Units
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

Required Core Subjects
18.03 Differential Equations, 12, REST; Calculus II (GIR)
20.110J Thermodynamics of Biomolecular Systems, 12, REST; Calculus II (GIR), Chemistry (GIR)

20.111J Physical Chemistry of Biomolecular Systems, 12; Calculus II (GIR), Chemistry (GIR), Physics I (GIR), Physics II (GIR)
5.12 Organic Chemistry, 12, REST; Chemistry (GIR)
20.109 Laboratory Fundamentals in Biological Engineering, 15, CI-M; Biology (GIR), Chemistry (GIR), 6.00, 18.03; 20.110
7.03 Genetics, 12, REST; Biology (GIR)
6.00 Introduction to Computer Science and Programming, 12, REST
5.07J Biological Chemistry I, 12, REST; 5.12

or 7.05 General Biochemistry, 12, REST; 5.12

7.06 Cell Biology, 12; 7.03, 7.05
20.310J Molecular, Cellular, and Tissue Biomechanics, 12; 2.370*, 18.03*, Biology (GIR)
20.320 Analysis of Biomolecular and Cellular Systems, 12; 20.110, 18.03, 6.00; 5.07
20.330J Fields, Forces, and Flows in Biological Systems, 12; 2.005*
20.390J Instrumentation and Measurement for Biological Systems, 12; Biology (GIR), Physics II (GIR), 6.00, 18.03; 20.330; 20.309; or permission of instructor
20.380J Biological Engineering Design, 12, CI-M; 7.06, 20.309

Restricted Electives (Tracks TBD) 21–24

Departmental Program Units That Also Satisfy the GIRs (36)

Unrestricted Electives 48

Total Units Beyond the GIRs Required for SB Degree 192–195

No subject can be counted both as part of the 17-subject GIRs and as part of the 192 units required beyond the GIRs. Every subject in the student's Departmental Program will count toward one or the other, but not both.

Notes
* Alternate prerequisites are listed in the subject description.
For an explanation of credit units, or hours, please refer to the online help in the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.

Core Subjects
20.102 Macropidemiology and Population Genetics
20.104J Environmental Risks for Common Diseases
20.106 Systems Microbiology

Laboratory Core
One of the following:
20.109 Laboratory Fundamentals in Biological Engineering
5.310 Laboratory Chemistry
7.02 Introduction to Experimental Biology and Communication
10.702 Introductory Experimental Biology and Communication

Restricted Electives
One of the following:
20.URG Undergraduate Research Opportunities
1.080 Environmental Chemistry and Biology
1.089 Environmental Microbiology
5.07 Biological Chemistry I
7.05 General Biochemistry
7.06 Cell Biology
7.28 Molecular Biology
22.01 Introduction to Ionizing Radiation

Inquiries
For further information on the undergraduate programs, please visit the Biological Engineering website at http://web.mit.edu/be/ or contact the BE Academic Office, Room 56-651, 617-253-1712.

GRADUATE STUDY

Doctoral Program in Biological Engineering
The Department of Biological Engineering offers a PhD program—and, in certain cases, an SM degree—with two tracks, one in bioengineering and another in applied biosciences. These tracks complement one another as a reflection of the importance of approaching quantitative biological and biomedical problems from the two perspectives. Students in either track may pursue research projects in any area by agreement with their research supervisor.

Graduate students in the Department of Biological Engineering can carry out their
research as part of a number of multi-investigator, multidisciplinary research centers at MIT, including the Center for Biomedical Engineering, the Biotechnology Process Engineering Center, the Center for Environmental Health Sciences, the Division of Comparative Medicine, and the Synthetic Biology Engineering Research Center. These opportunities include collaboration with faculty in the Schools of Engineering and Science, the Koch Institute for Integrative Cancer Research, the Whitehead Institute for Biomedical Research, and the Broad Institute, along with the Harvard University School of Medicine, Harvard University School of Dental Medicine, Harvard School of Public Health, and Boston University School of Medicine.

For both tracks, the written part of the doctoral qualifying examinations—centered on the respective core curriculum—is taken after the second term. The students select a research advisor and begin research before the end of the first year. The oral part of the doctoral qualifying examinations, which focuses on the student’s area of research, is taken during the second year. A total of approximately five years in residence is needed to complete the doctoral thesis and other degree requirements.

**Bioengineering Track**

Students admitted to the bioengineering track typically have a bachelor’s or master’s degree in engineering. During that first year, students pursue a unified core curriculum, in which engineering approaches are used to analyze biological systems and technologies over a wide range of length and time scales. The three core bioengineering subjects are:

- 20.420J Biomolecular Kinetics and Cellular Dynamics
- 20.430J Fields, Forces, and Flows in Biological Systems
- 20.440 Analysis of Biological Networks

These subjects bring central engineering principles to bear on the operation of biological systems from molecular to cell to tissue/organ levels. Foundational coursework in biochemistry and molecular cell biology is required, either before admission or during the first year of graduate study.

To enhance depth and breadth, the core subjects are supplemented by electives in the biological sciences and engineering. For doctoral candidates, two of these must be graduate-level biology subjects. The student will be expected to have biochemistry and cell biology as prerequisites and then select two graduate-level subjects in biological science. If biochemistry has not been taken previously, 7.51 should be selected and will count as one of these graduate-level subjects. If cell biology has not been taken previously, 7.06 should be selected but will not count as one of these graduate-level subjects. In addition, one graduate-level subject from a restricted set of Biological Engineering offerings beyond the core classes, and one additional engineering or science graduate-level subject, are required as electives.

The student selects a research advisor and begins research before the end of the first year. The oral part of the doctoral qualifying exams, which focuses on the student’s area of research, is taken during the second year. Approximately five years of total residence are needed to complete the doctoral thesis and other degree requirements.

The bioengineering track educates students to use engineering principles in the analysis and manipulation of biological systems, allowing them to solve problems across a spectrum of important applications. The curriculum is inherently interdisciplinary in that it brings together engineering and biology as fundamentally as possible and cuts across the boundaries of the traditional engineering disciplines.

The faculty members associated with this track possess a wide range of research interests within bioengineering. Areas in which students may specialize include systems and synthetic biology, biological and physiological transport phenomena; biological imaging and functional measurement; biomolecular engineering; cell and tissue engineering; computational modeling of biological and physiological systems; bioinformatics; design, discovery and delivery of molecular therapeutics; molecular, cell, and tissue biomechanics; and new tools for genomics, proteomics, and glycomics.

**Applied Biosciences Track**

Students admitted to the applied biosciences track typically have a bachelor’s or master’s degree in chemistry, biology, physics, or a related field. During the first year, students pursue a unified core curriculum, in which basic science approaches are applied to problems in the health and disease aspects of biomedical science. The three core subjects are:

- 20.420J Biomolecular Kinetics and Cellular Dynamics
- 20.440 Analysis of Biological Networks
- 20.450 Molecular and Cellular Pathophysiology

These subjects bring central scientific principles to bear on the operation of biological systems from molecular to cell to tissue to organismal levels. Foundational coursework in physics, calculus, organic chemistry, biochemistry, physical chemistry/biophysics/engineering, and cell biology/molecular biology/genetics is required, either before admission or during the first year of graduate study.

To enhance depth and breadth, the core subjects are supplemented by elective subjects. Doctoral candidates are expected to take elective subjects in biological science. If biochemistry has not been taken previously, 7.51 should be selected and will count as one of these graduate-level subjects. If cell biology has not been taken previously, 7.06 should be selected but will not count as one of these graduate-level subjects. In addition, one graduate-level subject from a restricted set of Biological Engineering offerings beyond the core classes, and one additional engineering or science graduate-level subject, are required as electives.

The applied biosciences track complements the bioengineering track by focusing on understanding the interactions of organisms with chemical, biological, and physical agents from the molecular to the systems level. The goal here is to apply systems approaches to studying the chemical and molecular pathways by which exogenous and endogenous agents induce toxicity and cause disease in humans; to establishing the molecular mechanisms of drug actions, with the longer-term aim of developing improved therapeutics; to establishing mechanisms of microbial pathogenesis; and to understanding and manipulating immune function.

Systems biology is an emerging field that involves quantitative study of biological
processes as integrated systems rather than as isolated parts. This goal of defining the behavior of the myriad of individual molecules requires quantitative models to unify the individual disciplines of physical chemistry, biochemistry, molecular biology, and cell physiology, as well as new tools for the simultaneous measurement of biological components, including small molecules, proteins, nucleic acids and complex carbohydrates.

The applied biosciences track provides rigorous training in the basic sciences, with application of chemistry, mathematics, biochemistry, molecular biology, cell biology, genetics, toxicology, and pharmacology to problems in human health and disease. Students receive preparation for careers in academic institutions, government agencies, and industry involving the application of modern methods of chemical, molecular, biological, and genetic analysis to the characterization of health risks.

Areas of research specialization within the program include systems and synthetic biology, development of in vitro models of the immune system and lymphoid tissue; development of molecular methods for direct measurement of mutations in humans; metabolism of foreign compounds; genetic toxicology; the molecular aspects and dosimetry of interactions between mutagens and carcinogens with nucleic acids and proteins; molecular mechanisms of DNA damage and repair; design and mechanisms of action of chemotherapeutic agents; environmental carcinogenesis and epidemiology; molecular mechanisms of carcinogenesis; cell physiology; extracellular regulation and signal transduction; and molecular and pathologic interactions between infectious microbial agents and carcinogens.

Master of Engineering in Biomedical Engineering
The Master of Engineering in Biomedical Engineering (MEBE) program is a five-year program leading to a bachelor’s degree in a science or engineering discipline along with a Master of Engineering in Biomedical Engineering. The program emphasizes the fusion of engineering with modern molecular-to-genomic biology, as in our SB and PhD degree programs. Admission to the MEBE program is open only to MIT undergraduate students, and requires candidates to demonstrate adequate quantitative and engineering credentials through their undergraduate coursework.

In addition to satisfying the requirements of their departmental program, candidates also are expected to complete subjects in differential equations (18.03); one engineering transport or systems subject (e.g., 2.005, 3.185, 6.002, 10.310); organic chemistry (5.12); biochemistry (7.05 or 5.07); and two of the core subjects from the Biomedical Engineering Minor.

Applications to the MEBE program are accepted from students in any of the departments in the School of Engineering or School of Science. Students interested in applying to the MEBE program should submit a standard MIT graduate application by the end of their junior year and are informed of the decision by the end of that summer.

Additional information on application procedures, objectives, and program requirements can be obtained by contacting the BE Academic Office, Room 56-651, be-acad@mit.edu.

Program Requirements
In addition to thesis credits, at least 66 units of coursework are required. At least 42 of these subject units must be from H-level graduate subjects. The remaining units may be satisfied with G-level subjects, or in some cases, with advanced undergraduate subjects. Of the 66 units, a minimum distribution in each of three categories is specified below.

Bioengineering Core
24 units selected from:
20.410 Molecular, Cellular, and Tissue Biomechanics
20.420 Biomolecular Kinetics and Cellular Dynamics
20.430 Fields, Forces, and Flows in Biological Systems

Biomedical Engineering Electives
Twenty-four units from A selection of G- or H-level subjects from various departments in the School of Engineering and HST. A list of suggested subjects is available from the BE Academic Office, Room 56-651.

Bioscience Elective
One biological science subject in addition to organic chemistry and biochemistry. This must be a laboratory subject if one was not taken as part of the student’s undergraduate curriculum.

Thesis
The student is required to complete a thesis that must be approved by the program director. The thesis is an original work of research, design, or development. If the supervisor is not a member of the Department of Biological Engineering, a reader who belongs to the BE faculty must also approve and sign the thesis. The student submits a thesis proposal by the end of the fourth year.

Inquiries
For further information on the graduate programs, please visit the Biological Engineering website at http://web.mit.edu/be/ or contact the BE Academic Office, Room 56-651, 617-253-1712.

Leaders for Global Operations Program
The 24-month Leaders for Global Operations (LGO) program combines graduate education in engineering and management for those with two or more years of full-time work experience who aspire to leadership positions in manufacturing or operations companies. A required six-month internship comprising a research project at one of LGO’s partner companies leads to a dual-degree thesis, culminating in two master’s degrees—an MBA (or SM in management) and an SM from Aeronautics and Astronautics. The program is offered jointly through the MIT Sloan School of Management and the School of Engineering. For more information, visit http://lgo.mit.edu/ or see the program description under Engineering Systems Division.
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K. Dane Wittrup, PhD
Professor of Chemical Engineering and Biological Engineering
Associate Director, Koch Institute for Integrative Cancer Research

Michael B. Yaffe, PhD
Professor of Biology and Biological Engineering

Ioannis V. Yannas, PhD
Professor of Mechanical and Biological Engineering

Associate Professors
Eric J. Alm, PhD
Associate Professor of Biological and Environmental Engineering
Edward S. Boyden, PhD
Associate Professor of Media Arts and Sciences and Biological Engineering
Bevin P. Engelward, DSc
Associate Professor of Biological Engineering
Ernest Fraenkel, PhD
Associate Professor of Biological Engineering
Jongyoon Han, PhD
Associate Professor of Electrical and Biological Engineering
Alan P. Jasanoff, PhD
Associate Professor of Nuclear Science and Engineering, Biological Engineering, and Brain and Cognitive Sciences

Krystyn Van Vliet, PhD
Associate Professor of Materials Science and Engineering and Biological Engineering

Christopher A. Voigt, PhD
Associate Professor of Biological Engineering
Codirector, Center of Integrative Synthetic Biology

Ron Weiss, PhD
Associate Professor of Biological Engineering
Director, Center of Integrative Synthetic Biology

Forest White, PhD
Associate Professor of Biological Engineering

Mehmet Fatih Yanik, PhD
Associate Professor of Biological Engineering and Electrical Engineering and Computer Science

Assistant Professors
Mark Bathe, PhD
Assistant Professor of Biological Engineering
Paul Blainey, PhD
Assistant Professor of Biological Engineering
Jacquin C. Niles, PhD, MD  
Assistant Professor of Biological Engineering

Katharina Ribbeck, PhD  
Assistant Professor of Biological Engineering

Jonathan Runstadler, DVM  
Assistant Professor of Biological Engineering

Feng Zhang, PhD  
Assistant Professor of Biological Engineering

**Visiting Professors**

Peter K. Sorger, PhD  
Visiting Professor of Biological Engineering

Matthew Meselson, PhD  
Visiting Professor of Biological Engineering

**Lecturers and Instructors**

Noubar Afeyan, PhD  
Laura C. Green, PhD  
Natalie Kuldell, PhD  
Mark Murcko, PhD  
Steven Nagle, PhD  
Agi Stachowiak, PhD  
Steve Wasserman, SM  
Alexander Wood, PhD

**Research Staff**

**Senior Research Scientist**

John S. Wishnok, PhD

**Research Scientists**

Robert G. Croy, PhD  
Michael DeMott, PhD  
Elena Gostjева, PhD  
William Gover, PhD  
Ramesh Indrakanti, PhD  
Vera Kolekova, PhD  
Rosa Liberman, PhD  
Dehua Zhao, PhD

**Postdoctoral Associates**

Jonathan Babb  
Mariya Barch  
Erika Bechtold  
Michael Beste  
Amanda Billings  
Eran Bram  
Sangwon Byun  
Ming-Wei Chao  
Ying-Ja Chen  
Rajdeep Chowdhury  
David Clarke  
Amanda Del Rosario  
Wenjun Deng  
Mituł Desai  
Bogdan Fedeles  
Aaron Gajadhar  
Boris Gavriloв  
Guanyu Gong  
Sara Gosline  
Patrick Guye  
Ta-Chun Hang  
Irena Jevтov  
Hannah Johnson  
Douglas Jones  
Do-Nyun Kim  
Chung Kim  
Charles Knutson  
Ravindra Kodihalli  
Taekwan Lee  
Victor Lelyveld  
Deyu Li  
Chunbo Lou  
Kun Lu  
Jesse Lyons  
Suresh Maddur Ganesan  
Aпротим Mazumder  
Tae Seok Moon  
Jason Neil  
Hung Nguyen  
Selim Olcum  
Keyao Pan  
Yan Ling Joy Pang  
Kavya Rakhra  
Tharathorn Rimchalа  
Ujjal Sarkar  
Daniel Sears  
Uthpala Seneviratne  
Nidhi Shrivastav  
Michael Smanski  
Mi Ryoung Song  
Bryнne Stanton  
Dan Su  
David Sukovich  
Juliesta Sylvestеr  
Nurcan Tuncbag  
Theresa Ulrich  
Leslie Woo  
Liliana Wroblewska  
Xiaofeng Xin  
Daiying Xu  
Wenjie Ye  
Ferah Yildirim

**Postdoctoral Fellows**

Jameel Zayed  
Hui Zhou

**Visiting Scientists**

Liyuan Bai, PhD  
Amelinda Bailey, PhD  
Yadunanda Budigi, PhD  
Luis de Carvalho, PhD  
Nicole Doyle, PhD  
Ulfеt Erkekoglu, PhD  
Steven Jay, PhD  
Megan McBеe  
Elba Serrаno, PhD

**Professor Emeritus**

Gerald N. Wogan, PhD  
Professor of Chemistry and Biological Engineering, Emeritus
Chemical engineering encompasses the translation of molecular information into discovery of new products and processes. It involves molecular transformations—chemical, physical, and biological—with multi-scale description from the submolecular to the macroscopic, and the analysis and synthesis of such systems. The chemical engineer is well prepared for a rewarding career in a strikingly diverse array of industries and professional arenas. Whether these industries are at the cutting edge—e.g. nanotechnology or biotechnology—or traditional, they depend on chemical engineers to make their products and processes a reality. The effectiveness of chemical engineers in such a broad range of areas begins with foundational knowledge in chemistry, biology, physics, and mathematics. From this foundation, chemical engineers develop core expertise in engineering thermodynamics, transport processes, and chemical kinetics, creating a powerful and widely applicable combination of molecular knowledge and engineering problem solving. To cope with complex, real-world problems, chemical engineers develop strong synthetic and analytic skills. Through creative application of these chemical engineering principles, chemical engineers create innovative solutions to important industrial and societal problems in areas such as development of clean energy sources, advancement of life sciences, production of pharmaceuticals, sustainable systems, and responsible environmental stewardship, and discovery and production of new materials.

The Department of Chemical Engineering at MIT offers three undergraduate programs. Course 10 leads to the Bachelor of Science in Chemical Engineering through a curriculum accredited by the Accreditation Board for Engineering and Technology (ABET). Course 10-B leads to the Bachelor of Science in Chemical-Biological Engineering, which includes the basic engineering core from the Course 10 degree and adds material in basic and applied biology. This degree is also accredited by ABET. Course 10-C leads to the Bachelor of Science without specification; this is not accredited and requires fewer chemical engineering subjects. Many undergraduates take advantage of graduate-level subjects in their upperclass years. Undergraduate students are also encouraged to participate in research through the MIT UROP program.

The department offers a broad selection of graduate subjects and research topics leading to advanced degrees in chemical engineering. Multidisciplinary approaches are highly valued, leading to strong ties with other MIT departments. In addition, the department maintains alliances, arrangements, and connections with institutions and industries worldwide. Areas for specialization include, but are not limited to: biochemical engineering, biomedical engineering, biotechnology, chemical catalysis, chemical process development, environmental engineering, fuels and energy, polymer chemistry, surface and colloid chemistry, systems engineering, and transport processes. Additional information may be found under Graduate Study below and on the department’s website.

The School of Chemical Engineering Practice (described below), leading to five-year bachelor’s and master’s degrees, involves one term of work under the direction of an Institute staff member resident at Practice School sites. This program provides students with a unique opportunity to apply basic professional principles to the solution of practical industrial problems.

UNDERGRADUATE STUDY

The undergraduate curriculum in chemical engineering provides basic studies in physics, biology, and mathematics, advanced subjects in chemistry or biology, and a strong core of chemical engineering. The four-year undergraduate programs provide students with the fundamentals of the discipline and allow some room for focus in subdisciplines or subjects that strengthen their preparation for advanced work.

In addition to science and engineering, students take an integrated sequence of subjects in the humanities and social sciences. Specific subject selection allows students to meet individual areas of interest. The curriculum provides a sound preparation for jobs in industry or government, and for graduate work in chemical engineering.

Chemical engineering also provides excellent preparation for careers in medicine and related fields of health science and technology. The department’s strong emphasis on chemistry and biology provides excellent preparation for medical school. Students interested in medical school work with their faculty and premedical advisor to create the best program. A minor in biomedical engineering is also available.

Bachelor of Science in Chemical Engineering/Course 10

This degree is intended for the student who seeks a broad education in the application of chemical engineering to a variety of specific areas, including energy and the environment, nanotechnology, polymers and colloids, surface science, catalysis and reaction engineering, systems and process design, and biotechnology. The degree requirements include the core chemical engineering subjects with a chemistry emphasis, and the opportunity to add subjects in any of these application areas.

Bachelor of Science in Chemical-Biological Engineering/Course 10-B

This degree is intended for the student who is specifically interested in the application of chemical engineering in the areas of biochemical and biomedical technologies. The degree requirements include core chemical engineering subjects and additional subjects in biological sciences and applied biology. This degree is excellent preparation for students also considering the biomedical engineering minor or medical school.

Students who decide early to major in either Course 10 or Course 10-B are encouraged to take subjects such as 5.111/5.112 Principles of Chemical Science, 5.12 Organic Chemistry I, and 10.10 Introduction to Chemical Engineering in their freshman year. Then 5.60, 18.03, 7.012/7.013/7.014, 10.213, and 10.301 may be taken in the sophomore year. The student is then well positioned for more in-depth and specialized subjects in the third and fourth years.

Some students may wish to defer choice of a major field or exercise maximum freedom during the first two years. If the Restricted Electives in Science and Technology (REST) Requirement subjects chosen in the second year include 18.03 and two subjects in the fields of fluid mechanics, thermodynamics, chemistry, biology, or chemical engineering, students can generally complete the requirements for a degree in chemical engineering in two more years. Students are advised to discuss their proposed program with a Course 10 faculty advisor as soon as they become interested in a degree in chemical engineering. Faculty advisors are assigned to students as soon as they declare their major and then work with the students through graduation. Further information may be obtained from Dr. Barry S. Johnston.
Bachelor of Science/Course 10-C

The curriculum for students in Course 10-C involves basic subjects in chemistry and chemical engineering. Instead of continuing in depth in these areas, students can add breadth by study in another field, such as another engineering discipline, biology, biomedical engineering, economics, or management. Course 10-C is attractive to students who wish to specialize in an area such as those cited above while simultaneously gaining a broad exposure to the chemical engineering approach to solving problems.

Departmental requirements for Course 10-C are:

- 5.60, 10.10, 10.213, 10.301, 10.302, and 18.03
- Plus one subject from the following:
  - 3.014; 6.152J; 5.36; 10.702J; 10.28 or 10.26/10.27/10.29
- And an additional subject from the above list or the following:
  - 6.021J, 6.033, 6.111, 6.805, 14.05, 15.279 or 15.301

All of the above restricted elective subjects satisfy the Institute CI-M requirement. Students must also complete 180 units beyond the GIRs; subjects chosen to complete these units must form a coherent program, and any subject chosen from the last list must be part of this coherent program.

Students planning to follow this curriculum should discuss their interests with their faculty advisor in the department at the time they decide to enter the Course 10-C program, and submit to Dr. Barry S. Johnston in the department’s Undergraduate Office a statement of goals and a coherent program of subjects no later than spring term of junior year. Please direct questions about this program to Dr. Johnston.
Bachelor of Science in Engineering as Recommended by the Department of Chemical Engineering/Course 10-Eng

The 10-ENG degree program is designed to offer flexibility within the context of chemical engineering while ensuring significant engineering content, and is a complement to our chemical engineering degree programs 10 and 10-B. The department will be seeking accreditation by ABET for 10-ENG as an Engineering degree. The degree is designed to enable students to pursue a deeper level of understanding in a specific interdisciplinary field that is relevant to the chemical engineering core discipline. The degree requirements include all of the core chemical engineering coursework, plus a chosen set of three foundational concept subjects and four subjects with engineering content that make up a comprehensive concentration specific to the interdisciplinary area selected by the student. The concentrations have been selected by the Department of Chemical Engineering to represent new and developing cross-disciplinary fields that are relevant to the chemical engineering core discipline. The degree requirements include all of the core chemical engineering coursework, plus a chosen set of three foundational concept subjects and four subjects with engineering content that make up a comprehensive concentration specific to the interdisciplinary area selected by the student. The concentrations have been selected by the Department of Chemical Engineering to represent new and developing cross-disciplinary areas that benefit from a strong foundation in engineering within the chemical engineering context. Details of the concentrations are available from the Chemical Engineering Student Office and the department’s website.

The foundational concept component of the flexible engineering degree consists of basic science and engineering subjects that help lay the groundwork for the chosen concentration. Three subjects must be selected from a list of potential topics. One of the foundational concept subjects must be a chemical engineering CI-M subject, and one must be a laboratory subject that satisfies the Institute Laboratory Requirement. The subjects should be selected with the assistance of a 10-ENG degree advisor from the Chemical Engineering Department so as to be consistent with the degree requirements of the program and the General Institute Requirements. Several of these subjects can satisfy the program’s CI-M requirement.

The flexible engineering concentration consists of four subjects that are selected by the student from a suggested subject list provided for each 10-ENG concentration; the student also may propose subjects that fit the theme of the chosen concentration. These lists are included in the concentration descriptions provided on the department’s website and at the Chemical Engineering Student Office. Students work with their 10-ENG advisors to propose a 10-ENG degree program, which must then be approved by the Chemical Engineering Undergraduate Committee.

The flexible engineering degree major capstone experience consists of 12 units total from any combination of the Integrated Chemical Engineering (10.490 or 10.492) or the Integrated Chemical Engineering-Topic subjects (10.493, 10.494) and/or a senior-level project. Alternatively, the student may choose to complete a senior thesis in a topic area relevant to the concentration. Senior-level projects or senior thesis projects are specifically designed to integrate engineering principles into specific applications or problems and are not standard undergraduate research (UROP) projects; such projects require the preliminary approval of the department’s undergraduate officer.

Five-Year Programs and Joint 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 Student Office. Students in the five-year program normally enroll in the School of Chemical Engineering Practice.

For chemical engineering students interested in nuclear applications, the Department of Chemical Engineering and the Department of Nuclear Engineering offer a five-year program leading to the joint Bachelor of Science in Chemical Engineering and Master of Science in Nuclear Engineering. Such programs are approved on an individual basis between the registration officers of the two departments.

Inquiries

Additional information concerning undergraduate academic and research programs may be obtained by writing to Dr. Barry S. Johnston, undergraduate officer, Department of Chemical Engineering, Room 66-368, 617-258-7141, fax 617-258-0546. For information regarding admissions and financial aid, contact the Admissions Office, Room 3-108, 617-253-4791.

Graduate Study

Graduate study provides both rigorous training in the fundamental core discipline of chemical engineering and the opportunity to focus on specific subdisciplines. In addition to completing the four core subject requirements in thermodynamics, reaction engineering, numerical methods, and transport phenomena, students select a research advisor and area for specialization, some of which are discussed below.

Thermodynamics and Molecular Computation. Thermodynamics is a cornerstone of chemical engineering. Processes as diverse as chemical production, bioreaction, creation of advanced materials, protein separation, and environmental treatment are governed by thermodynamics. The classical concepts of equilibrium, reversibility, energy, and entropy are basic to the analysis and design of these processes.
Bachelor of Science in Chemical-Biological Engineering/Course 10-B

General Institute Requirements (GIRs)

<table>
<thead>
<tr>
<th>Science Requirement</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>8</td>
</tr>
</tbody>
</table>

Restricted Electives in Science and Technology (REST) Requirement can be satisfied from among 5.07, 5.12, 5.60, 7.03, 7.05, 10.301, and 18.03 or 18.034 in the Departmental Program.

Laboratory Requirement can be satisfied by 7.02 or 10.702.

Total GIR Subjects Required for SB Degree

17

Communication Requirement

The program includes a Communication Requirement of 4 subjects:

- 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and
- 2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program

Subject names below are followed by credit units, and by prerequisites, if any (carequisites in italics)

<table>
<thead>
<tr>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.12 Organic Chemistry I, 12, REST; Chemistry (GIR)</td>
<td>186</td>
</tr>
<tr>
<td>5.60 Thermodynamics and Kinetics, 12, REST; Calculus II (GIR), Chemistry (GIR)</td>
<td>10.702</td>
</tr>
<tr>
<td>10.201 Introduction to Experimental Biology and Communication, 18, CI-M, LAB; Biology (GIR)</td>
<td>7.03</td>
</tr>
<tr>
<td>7.05 General Biochemistry, 12, REST; 5.12*</td>
<td>7.06</td>
</tr>
<tr>
<td>or 5.07 Biological Chemistry I, 12, REST; 5.12</td>
<td>7.06</td>
</tr>
<tr>
<td>10.201 Chemical-Biological Engineering Laboratory, 15, CI-M; 7.05; 10.702*; or permission of instructor</td>
<td></td>
</tr>
</tbody>
</table>

or one of the following three subjects:

- 10.26 Chemical Engineering Projects Laboratory, 15, CI-M; 5.310*; 10.302; or permission of instructor
- 10.27 Energy Engineering Projects Laboratory, 15, CI-M; 5.310*; 10.302; or permission of instructor
- 10.29 Biological Engineering Projects Laboratory, 15, CI-M; 5.310*; 10.302; or permission of instructor

10.301 Fluid Mechanics, 12, REST; 18.03, 10.10

10.302 Transport Processes, 12; 5.60, 10.301, 10.213; or permission of instructor

plus

10.37 Chemical Kinetics and Reactor Design, 9; 5.60, 10.301

10.490 Integrated Chemical Engineering I, 8; 10.37

10.491 Integrated Chemical Engineering II, 8; 10.490

plus two of the following three subjects:

10.492 Integrated Chemical Engineering Topics I, 4; 10.301 and permission of instructor

10.493 Integrated Chemical Engineering Topics II, 4; 10.301 and permission of instructor

10.494 Integrated Chemical Engineering Topics III, 4; 10.301 and permission of instructor

18.09 Differential Equations, 12, REST; Calculus II (GIR)

or

18.034 Differential Equations, 12, REST; Calculus II (GIR)

Departmental Program Units That Also Satisfy the GIRs

(36)

Unrestricted Electives

48

Total Units Beyond the GIRs Required for SB Degree

198

No subject can be counted both as part of the 12-subject GIRs and as part of the 198 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

Notes

*Alternate prerequisites are listed in the subject description.

For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.
a complex pharmaceutical molecule, the specialized reactions of proteins and metabolism. Chemical kinetics is the chemical engineer’s tool for understanding chemical change.

A catalyst influences the reaction rate. Catalysts are sought for increasing production, improving the reaction conditions, and emphasizing a desired product among several possibilities. The challenge is to design the catalyst, to increase its effectiveness and stability, and to create methods to manufacture it.

A chemical reactor should produce a desired product reliably, safely, and economically. In designing a reactor, the chemical engineer must consider how the chemical kinetics, often modified by catalysis, interacts with the transport phenomena in flowing materials. New microreactor designs are expanding the concept of what a reactor may do, how reactions may be conducted, and what is required to scale a process from laboratory to production.

Research is being conducted in the department at the forefront of catalyst design, complex chemical synthesis, bioreactor design, surface and gas-phase chemistry, miniaturization of reactors, mathematical modeling of chemical reaction networks, and many other areas of chemical reaction engineering. Applications include the manufacturing of chemicals, refining of fuels for transportation and power, and microreactors for highly reactive or potentially hazardous materials.

Polymers. Wondrous materials found in nature and now synthesized in enormous quantity and variety, polymers find an ever-increasing use in manufactured products. Polymers are versatile because their properties are so wide-ranging, as is evident even in the conceptually simple polymers made from a single molecular species. The versatility becomes more profound in the copolymers made from multiple precursors, and the polymers compounded with filler materials. Research in polymers encompasses the chemical reactions of their formation, methods of processing them into products, means of modifying their physical properties, and the relationship between the properties and the underlying molecular- and solid-phase structure.

Graduate research opportunities in the department include studies of polymerization kinetics, non-Newtonian rheology, polymer thin films and interfaces, block copolymers, liquid crystalline polymers, nanocomposites and nano-fibers, self-assembly and patterning, and many other areas of polymer science and engineering. In addition to a program in graduate study in polymers within the department, the interdisciplinary Program in Polymer Science and Technology (PPST) provides a community for researchers in the polymer field and offers a program of study that focuses on the interdisciplinary nature of polymer science and engineering.

Materials. The inorganic compounds found in nature are the basis for new materials made by modifying molecular composition (such as purifying silicon and doping it with selected impurities) and structure (such as control of pore and grain size). These materials have electronic, mechanical, and optical properties that support a variety of novel technologies. Other materials are applied as coatings—thin films that create a functional surface. Still other materials have biological applications, such as diagnostic sensors that are compatible with living tissue, barriers that control the release of pharmaceutical molecules, and scaffolds for tissue repair. A new generation of biomaterials is being derived from biological molecules. Research in materials is wide-ranging and highly interdisciplinary, both fundamental and applied. In the department, materials research includes studies in plasma etching, thin-film chemical vapor deposition, crystal growth, nano-crystalline structure, molecular simulation, scaffolds for bone and soft tissue regeneration, biocompatible polymers, and many other areas of materials engineering.

Surfaces and Nanostructures. In many arrangements of matter, the interfaces between phases—more than their bulk compositions—are critical to the material structure and behavior. The surfaces of solids offer a platform for functional coating; coatings may be deposited from vapor, applied as a volatile liquid, or assembled from solution onto the solid, in a pattern determined by the molecular properties. This self-assembly tendency may be exploited to arrange desired patterns that have operational properties. Interfacial effects are also responsible for stable dispersions of immiscible phases, leading to fluids with complex microstructure. Other structured fluids arise from large molecules whose orientation in the solvent is constrained by molecular size and properties. In solids, tight control of pore size, grain size, chemical composition, and crystal structure offer a striking range of catalytic, mechanical, and electromagnetic properties. The understanding of gas-solid kinetics is crucial to the study of heterogeneous catalysis and integrated circuit fabrication. Structure is the basis for function, and by manipulating tiny length scales, the resulting nanostructure makes available new capabilities, and thus new technologies and products. Graduate study in surfaces and nanostructures may include studies of colloids, emulsions, surfactants, and other structured fluids with biological, medical, or environmental applications. It also encompasses thin films, liquid crystals, sol-gel processing, control of pharmaceutical morphology, nanostructured materials, carbon nanotubes, surface chemistry, surface patterning, and many other areas of nanotechnology and surface science.

Biological Engineering. Chemical engineering thermodynamics, transport, and chemical kinetics, so useful for manufacturing processes, are fruitful tools for exploring biological systems as well. Biological engineering research may be directed at molecular-level processes, the cell, tissues, the organism, and large-scale manufacturing in biotech processes. It may be applied to producing specialized proteins, genetic modification of cells, transport of nutrients and wastes in tissue, therapeutic methods of drug delivery, tissue repair and generation, purification of product molecules, and control strategies for complex bioproduction plants. Its methods include analytical chemistry and biochemistry techniques, bioinformatic processing of data, and computational solution of chemical reaction and transport models. Biological engineering is an extraordinarily rich area for chemical engineers, and its consequences—theoretical, medical, commercial—will be far-reaching.

Opportunities in the department for graduate study in biological engineering include manipulation and purification of proteins and other biomolecules, research into metabolic processes, tissue regeneration, gene regulation, bioprocesses, bioinformatics, drug delivery, and biomaterials, to name a few. Both experimental and computational methods are used, including statistical mechanics and systems theory. Chemical engineering faculty are also involved in the Center for Biomedical Engineering, created to enhance interdisciplinary research and
education at the intersection of engineering, molecular and cell biology, and medicine. The Novartis-MIT Center for Continuous Manufacturing, another center of research activity involving chemical engineers, promises to revolutionize the chemical processing of pharmaceuticals.

Energy and Environmental Engineering. Making energy available to society requires finding and producing a range of fuels, improving the efficiency of energy use under the ultimate limits imposed by thermodynamics, and reducing the effects of these processes on the environment. The widespread use of fossil fuels increases the amount of carbon dioxide in the atmosphere, leading to concerns about global warming. Other sustainability indicators also suggest that we now need to transform our energy system to a more efficient, lower-carbon future. This transformation provides many opportunities for chemical engineers to evaluate and explore other energy supply options such as renewable energy from solar, biomass, and geothermal resources, nonconventional fuels from heavy oils, tar sands, natural gas hydrates, and oil shales. Developing technologies for transporting and storing thermal and electrical energy over a range of scales are also of interest.

Further environmental distress can result from manufacturing processes and society’s use of the manufactured products. The traditional response of treating process wastes is still useful, but there is growing emphasis on designing new processes to produce less waste. This might be done by improving catalysts to decrease unwanted by-products, finding alternatives to volatile solvents, and developing more effective separation processes. Chemical engineers are at work in all these areas, as well as developing alternative energy sources and assessing the effects of pollutants on human health.

In the department, students will find expertise in combustion, chemical reaction networks, renewable energy and upgrading of nonconventional fuels, carbon dioxide capture and sequestration, water purification and catalytic treatment of pollutants, global air pollution modeling, design of novel energy conversion processes, energy supply chains, and many other areas of energy and environmental engineering. Faculty in the department are actively involved in the MIT Energy Initiative.

Bachelor of Science in Engineering as Recommended by the Department of Chemical Engineering/Course 10-ENG

<table>
<thead>
<tr>
<th>General Institute Requirements (GI Rs)</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>8</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement [can be satisfied from among 5.60, 10.301, or 10.803 or in the Departmental Program]</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement [can be satisfied by 1.106 and 1.107, or 2.671, 3.014, 5.310, 10.467, 10.702, or 12.335 in the Departmental Program ]</td>
<td>1</td>
</tr>
<tr>
<td>Total GIR Subjects Required for SB Degree</td>
<td>17</td>
</tr>
</tbody>
</table>

<table>
<thead>
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</tr>
<tr>
<td>2 subjects designated as Communication Intensive in the Major (CI-M).</td>
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</tr>
</thead>
<tbody>
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<td>Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics)</td>
</tr>
<tr>
<td>Required Subjects</td>
</tr>
<tr>
<td>5.60 Thermodynamics and Kinetics, 12, REST; Calculus II (GIR)</td>
</tr>
<tr>
<td>18.03 Differential Equations, 12, REST; Calculus II (GIR)</td>
</tr>
<tr>
<td>10.10 Introduction to Chemical Engineering, 12; Physics I (GIR), Calculus I (GIR), Chemistry (GIR)</td>
</tr>
<tr>
<td>10.213 Chemical and Biological Engineering Thermodynamics, 12; 5.60, 10.10</td>
</tr>
<tr>
<td>10.301 Fluid Mechanics, 12, REST; 18.03, 10.10</td>
</tr>
<tr>
<td>10.303 Transport Processes, 12; 5.60, 10.301, 10.213; or permission of instructor</td>
</tr>
<tr>
<td>10.37 Chemical Kinetics and Reactor Design, 9; 5.60, 10.301</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Foundational Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>All subjects are suitable for any concentration within the program. In consultation with the advisor, students can select one subject from each of the three groups. Students may not exceed the 45-unit cap except by petition.</td>
</tr>
</tbody>
</table>

**Group I. Choose one of the following Course 10 CI-M subjects:**

| 10.26 Chemical Engineering Projects Laboratory, 15, CI-M; 5.310*; 10.302; or permission of instructor |
| 10.27 Energy Engineering Projects Laboratory, 15, CI-M; 5.310*; 10.302; or permission of instructor |
| 10.28 Chemical-Biological Engineering Laboratory, 15, CI-M; 7.05*; 10.702T*; or permission of instructor |
| 10.29 Biological Engineering Projects Laboratory, 15, CI-M; 5.310*; 10.302; or permission of instructor |
| 10.467 Polymer Science Laboratory, 15, LAB, CI-M*; 5.12; 5.310* |

**Group II. Choose one of the following Institute Laboratory subjects:**

| 1.106 Environmental Fluid Transport Processes and Hydrology Laboratory, 6, LAB*; 1.061, 1.070 and 1.071 |
| 1.107 Environmental Chemistry and Biology Laboratory, 6, LAB*; 1.080 |
| 2.671 Measurement and Instrumentation, 12, LAB, CI-M; 2.001, 2.003J, Physics II (GIR) |
| 3.014 Materials Laboratory, 12, LAB, CI-M* |
| 5.310 Laboratory Chemistry, 12, LAB, CI-M; 5.12 |
| 5.35 Introduction to Experimental Chemistry, 12, LAB; Chemistry (GIR) |
| —Module 1 Survey of Spectroscopy, 4 |
| —Module 2 Inorganic Synthesis and Kinetics, 4; Module 1 |
| —Module 3 Polymeric Light Emitting Devices, 4; 5.12; Module 2 |
| 10.702J Introduction to Experimental Biology and Communication, 18, CI-M, LAB*; Biology (GIR) |
| 12.335 Experimental Atmospheric Chemistry, 12, LAB, CI-M*; Chemistry (GIR) |
| 20.109 Laboratory Fundamentals in Biological Engineering, 15, LAB, CI-M*; Biology (GIR), Chemistry (GIR), 6.00, 18.03; 20.110* |

**Group III. Choose one of the following:**

| 1.00 Introduction to Computers and Engineering Problem Solving, 12, REST; Calculus I (GIR) |
| 1.018 Ecology I: The Earth System, 12, REST, CI-M* |
| 1.080 Environmental Chemistry, 12; Chemistry (GIR) |
| 3.012 Fundamentals of Materials Science and Engineering, 15, REST T*; 18.93* |
| 3.155 Micro/ Nano Processing Technology, 12, CI-M*; permission of instructor |
| 5.12 Organic Chemistry I, 12, REST; Chemistry (GIR) |
| 5.61 Physical Chemistry, 12, REST; Physics II (GIR), Calculus II (GIR), Chemistry (GIR) |
| 6.00 Introduction to Computer Science and Programming, 12, REST |
| 7.03 Genetics, 12, REST*; Biology (GIR) |
| 8.21 Physics of Energy, 12, REST*; Physics II (GIR), Calculus II (GIR), Chemistry (GIR) |
Part and product systems engineering brings it all together, placing the technical features of a process or product in the context of operations, economics, and business. The end result is improved economy, reliability, and safety. Methodologies for process and product modeling and simulation, computer-aided engineering, operations research, optimization theory and algorithms, process and product design strategy, treatment of uncertainty, multiscale systems engineering, and many other areas of systems engineering are being developed in the Department of Chemical Engineering. Such research leads to new prototypes for process systems, design of new molecules with desired properties, and processes with better operability, control, safety, and environmental performance.

Systems Design and Simulation. From early in the development of chemical engineering, processes were represented as combinations of unit operations. This concept was useful in analyzing processes, as well as providing a library of building blocks for creating new processes. Process and product design are imaginative activities, an artful blend of intuition and analysis. Design is aided by mathematical tools that simulate the behavior of the process or product and seek optimum performance. Effective use of simulation and optimization tools allows unexpected pathways to be explored, dangerous operating regions to be identified, and transient and accident conditions to be tested. Process and product systems engineering brings it all together, placing the technical features of a process or product in the context of operations, economics, and business. The end result is improved economy, reliability, and safety. Methodologies for process and product modeling and simulation, computer-aided engineering, operations research, optimization theory and algorithms, process and product design strategy, treatment of uncertainty, multiscale systems engineering, and many other areas of systems engineering are being developed in the Department of Chemical Engineering. Such research leads to new prototypes for process systems, design of new molecules with desired properties, and processes with better operability, control, safety, and environmental performance.

School of Chemical Engineering Practice

Since 1916, the David H. Koch School of Chemical Engineering Practice has been a major feature of the graduate education in the department. In this unique program, students receive intensive instruction to broaden their education not only in the technical aspects of the profession, but also in communication skills and human relations, which are frequently decisive factors in the success of an engineering enterprise. The Practice School program stresses problem solving in an engineering internship format, where students undertake projects at industrial sites under the direct supervision of resident MIT faculty. Credit is granted for participation in the Practice School in lieu of preparing a master’s thesis.

The operation of the Practice School is similar to that of a small consulting company. The resident staff work closely with the technical personnel of the host companies in identifying project assignments with significant educational merit, and with solutions that make important contributions to the operation of the company.

During Practice School, students work on three or four different projects. Groups and designated group leaders change from one project to another, giving every individual an opportunity to be a group leader at least once.

Students in the Practice School program are required to demonstrate proficiency, or take one graduate subject, in each of the following areas: thermodynamics, heat and mass transfer, applied process chemistry, kinetics and reactor design, systems engineering, and applied mathematics.

Master of Science in Chemical Engineering

Programs for the Master of Science in Chemical Engineering usually are arranged as a continuation of undergraduate professional training, but at a greater level of depth and maturity. The general requirements for a master’s program are given in the section on Graduate Education in Part 1. To complete the requirement of at least 66 subject units, of which 42 units must be in H-level subjects, together with an acceptable thesis, generally takes four terms.
Master of Science in Chemical Engineering Practice
The unit requirements for the Master of Science in Chemical Engineering Practice (Course 10-A) are the same as those for the Master of Science in Chemical Engineering, except that 48 units of Practice School experience replace the master’s thesis.

In some cases, Bachelor of Science graduates of this department can meet the requirements for the Master of Science in Chemical Engineering Practice (Course 10-A) in two terms. Beginning in September following graduation, students complete the required coursework at the Institute. The spring semester is spent at the Practice School field stations. Careful planning of the senior year schedule is important.

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 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.

Master of Science in Technology and Policy
The Master of Science in Technology and Policy is an engineering research degree with a strong focus on the role of technology in policy analysis and formulation. The Technology and Policy Program (TPP) curriculum provides a solid grounding in technology and policy by combining advanced subjects in the student’s chosen technical field with subjects in economics, politics, and law. Many students combine TPP’s curriculum with complementary subjects to obtain dual degrees in TPP and either a specialized branch of engineering or an applied social science such as political science or urban studies and planning. For additional information, see the program description under Engineering Systems Division or visit http://web.mit.edu/tpp/.

Leaders for Global Operations Program
The 24-month Leaders for Global Operations (LGO) program combines graduate education in engineering and management for those with two or more years of full-time work experience who aspire to leadership positions in manufacturing or operations companies. A required six-month internship comprising a research project at one of LGO’s partner companies leads to a dual-degree thesis, culminating in two master’s degrees—an MBA (or SM in management) and an SM from Aeronautics and Astronautics. The program is offered jointly through the MIT Sloan School of Management and the School of Engineering. For more information, visit http://lgo.mit.edu/ or see the program description under Engineering Systems Division.

Doctor of Science or Doctor of Philosophy
Doctoral candidates are required to pass a written general examination early in their program of study. Given in January and May, the written examination is usually taken at the end of the first term in residence as a graduate student. There is also an oral general examination, which consists of the presentation of a thesis proposal to a faculty committee; this is normally done during the second year of residence. Completing a master’s degree is not a prerequisite for entering the doctoral program or obtaining a doctoral degree.

The requirements for the doctoral degree include a program of advanced study, a minor program, a biology requirement, 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. A thesis committee of selected faculty monitors the doctoral program of each candidate.

Doctor of Philosophy in Chemical Engineering Practice
This degree program provides educational experience that combines advanced work in manufacturing, independent research, and management. The program is built on the outstanding research programs within the department, the unique resources of the David H. Koch School of Chemical Engineering Practice, and the world-class resources of the Sloan School of Management. Students are prepared for a rapid launch into positions of leadership in industry and provided with a foundation for completion of an MBA degree.

The program consists of three major parts: the first year is devoted to coursework and the Practice School, the two middle years are devoted to research, and the final year is completed in the Sloan School of Management. In addition, an integrative project combines the research and management portions of the program.

Students in the PhD in Chemical Engineering Practice (PhDCEP) program must pass the department’s written and oral examinations. The progress of their research is monitored by a faculty committee, and the final thesis document is defended in a public forum. The normal completion time should be four calendar years for the PhDCEP program.

Other Graduate Opportunities
The Program in Polymer Science and Technology is intended for students who seek a Doctor of Science or Doctor of Philosophy degree with a focus on macromolecular science and engineering. This program is described under Interdisciplinary Graduate Programs in Part 3.

Financial Support
The department has a wide variety of financial support options for graduate students, including teaching and research assistantships, fellowships, and loans. Information about financial assistance may be obtained by writing to the Graduate Student Office, but consideration for awards cannot be given before admissions decisions have been made.

Inquiries
For additional information concerning graduate programs, admissions, financial aid, and assistantships, contact the Graduate Student Office, Department of Chemical Engineering, Room 66-366, 617-253-4579, chemegrad@mit.edu.
**Faculty and Staff**

**Faculty and Teaching Staff**

Klavs F. Jensen, PhD  
Warren K. Lewis Professor of Chemical Engineering  
Department Head  
William H. Green, PhD  
Hoyt C. Hotzel Professor of Chemical Engineering  
Executive Officer  

**Professors**

Robert C. Armstrong, PhD  
Chevron Professor of Chemical Engineering  
Professor of Chemical Engineering  
Deputy Director, MIT Energy Initiative  
Paul I. Barton, PhD  
Lammot du Pont Professor of Chemical Engineering  
Martin Z. Bazant, PhD  
Professor of Chemical Engineering and Applied Mathematics  
Daniel Blankschtein, PhD  
Professor of Chemical Engineering and Applied Mathematics  
Richard D. Braatz, PhD  
Edwin R. Gilliland Professor of Chemical Engineering  
Arup K. Chakraborty, PhD  
Robert T. Haslam Professor of Chemical Engineering  
Professor of Chemistry and Biological Engineering  
Robert E. Cohen, PhD  
Raymond A. and Helen E. St. Laurent Professor of Chemical Engineering  
Codirector, DuPont-MIT Alliance  
Chair, PhD in Chemical Engineering Practice Steering Committee  
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Professor of Chemical Engineering  
Charles L. Cooney, PhD  
Robert T. Haslam Professor of Chemical and Biochemical Engineering  
Faculty Director, Deshpande Center for Technological Innovation  
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Associate Dean of Engineering for Research  
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David H. Koch Professor in Engineering  
T. Alan Hatton, PhD  
Ralph Landau Professor of Chemical Engineering Practice  
Director, David H. Koch School of Chemical Engineering Practice  
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David H. Koch Institute Professor  
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Associate Member, Broad Institute  
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Arthur Dehon Little Professor of Chemical Engineering  
Gregory Stephanopoulos, PhD  
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Michael S. Strano, PhD  
Charles and Hilda Roddye Professor of Chemical Engineering  
Bernhardt L. Trout, PhD  
Professor of Chemical Engineering  
Director, Novartis-MIT Center for Continuous Manufacturing  
Cochair, Singapore-MIT Alliance, Chemical and Pharmaceutical Engineering  
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Professor of Chemical Engineering  
Institute Professor  
Karl D. Wittrup, PhD  
Carbon P. Dubbs Professor of Chemical Engineering and Biological Engineering  

**Associate Professors**

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Latham Family Career Development Associate Professor  
Kristala J. Prather, PhD  
Miller Associate Professor of Chemical Engineering  
Preetinder S. Virk, ScD  
Associate Professor of Chemical Engineering  

**Assistant Professors**

Fikile R. Brushett, PhD  
Assistant Professor of Chemical Engineering  
Jesse H. Kroll, PhD  
Assistant Professor of Civil and Environmental Engineering and Chemical Engineering  
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Assistant Professor of Chemical Engineering  
Bradley D. Olsen, PhD  
Raymond A. and Helen St. Laurent Assistant Professor of Chemical Engineering  
Yuriy Román, PhD  
Assistant Professor of Chemical Engineering  
Hadley D. Sikes, PhD  
Joseph R. Mares Assistant Professor of Chemical Engineering  
William A. Tisdale, PhD  
Assistant Professor of Chemical Engineering  

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Barry S. Johnston, PhD  
Undergraduate Officer  
Claude Lupis, PhD
**Lecturers**
Bonnie D. Burrell, BA  
William H. Dalzell, PhD

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Veyssel Kayser  
Fritz Simeon  
Forrest Whitcher

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Lev E. Bromberg  
Joanne K. Kelleher  
Luis Perez-Breva

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Rachael Hogan  
Ashley King  
Narmin Tahiroya  
Christopher Testa  
Brittany Thomas  
Wuhbet Abraham

**Visiting Scientists**
Moon Chan Kim  
Bangzhu Peng  
Yushi Suzuki

**Professors Emeriti**
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Gregory J. McRae, PhD  
Hoyt C. Hottel Professor of Chemical Engineering, Emeritus

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Professor of Chemical and Electrical Engineering, Emeritus  
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Edwin R. Gilliland Professor of Chemical Engineering, Emeritus  
Jefferson W. Tester, PhD  
Herman P. Meissner Professor of Chemical Engineering, Emeritus  
James Wei, ScD  
Professor of Chemical Engineering, Emeritus
The Department of Civil and Environmental Engineering focuses on interactions between human activities and the natural environment. Its mission is to use science, engineering, and policy to improve quality of life and sustain environmental systems. This includes intelligent use of natural resources such as the raw materials, energy, and ecosystems needed to sustain modern society. It also includes the design of functional and environmentally compatible facilities and infrastructure. Within this broad context, the Department of Civil and Environmental Engineering is especially concerned with:

- Understanding of natural cycles, systems, and processes relevant to human activities
- Use of natural analogs to help design new materials, industrial processes, and infrastructure systems
- Development of new building and transportation technologies
- Advances in information infrastructure and logistics
- Creation of attractive and sustainable physical environments

An education in civil and environmental engineering provides an excellent foundation for careers in fields as diverse as engineering design, education, law, medicine, and public health, as well as for graduate study in engineering and science. Our graduates teach and carry out research in universities, work for large firms, start their own businesses, and take positions in government and nonprofit organizations. As pressures on limited natural resources grow, there will be increasing demand for engineers who understand how to make best use of these resources in the products and services they design. The department’s undergraduate program recognizes this need by providing background in science and engineering fundamentals while also emphasizing hands-on design projects and case studies that provide context and motivation. Students are taught how to combine theory, measurement, and modeling to develop a good understanding of the problem at hand and to point the way to desirable solutions.

The department offers two designated undergraduate degrees accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET). The Bachelor of Science in Civil Engineering provides a solid foundation for practice in both classical and newly developing areas of civil engineering, including structural analysis and design, engineering materials, geotechnical analysis and design, sustainable built environments, and transportation and logistics. The Bachelor of Science in Environmental Engineering Science emphasizes the fundamental physical, chemical, and biological processes necessary for understanding the interactions between man and the environment. Issues considered include the provision of clean and reliable water supplies, flood forecasting and protection, development of renewable and nonrenewable energy sources, causes and implications of climate change, and the impact of human activities on natural cycles. Both programs provide awareness of the socio-political context in which civil and environmental engineering problems are solved. Premedical students may satisfy medical school entrance requirements while earning the accredited degree in environmental engineering science with proper planning of their program. A third degree is offered for students who want more flexibility. Typical examples are students who will pursue careers in medicine, law, or scientific research.

The undergraduate programs in civil engineering and environmental engineering science share a common sophomore year that emphasizes mathematics, mechanics, ecology, and design. The ecology sequence begins by considering how natural systems work and then turns to a consideration of interactions between these systems and human activities. This sequence provides a scientific context for a consideration of sustainable design in subsequent subjects. Sophomore students from all programs work together in teams on design projects that synthesize concepts taught in the core subjects. In the junior and senior years, students from the two programs concentrate on disciplinary subjects that provide depth in each specialty. During the final term of the senior year, all students come together again in an advanced design subject that integrates lessons learned throughout the undergraduate education. There is ample room in the program for electives and minors that can be used to tailor each student’s program to individual needs.

The department offers advanced degrees within the broadly defined areas of environmental science and engineering (which includes environmental chemistry, environmental fluid mechanics and coastal engineering, environmental microbiology, and hydrology and hydroclimatolgy), geotechnical engineering and geomechanics, mechanics of materials and structures, and transportation. The depth and breadth of coursework and research required differ for each degree program.

The degrees offered are Master of Engineering (MEng), Master of Science in Transportation (MST), Master of Science (SM), Civil Engineer’s degree, Doctor of Philosophy (PhD), and Doctor of Science (ScD).

**UNDERGRADUATE STUDY**

The Department of Civil and Environmental Engineering offers three undergraduate programs: Course 1-C, leading to the Bachelor of Science in Civil Engineering, Course 1-E, leading to the Bachelor of Science in Environmental Engineering Science, and Course 1-A, leading to the Bachelor of Science as recommended by the Department of Civil and Environmental Engineering.

Each of these programs is flexible enough to allow students to pursue special interests by taking additional subjects in the Department of Civil and Environmental Engineering and in other departments. Undergraduates are encouraged to participate in the research activities of the department and in many cases obtain degree credit for such work.

In general, students find advantages in planning their programs for the third and fourth years so that they dovetail with possible graduate study, including the department’s Master of Engineering degree. This is readily accomplished by those students who embark on the departmental program in their second year. Under certain circumstances, students are permitted to work toward receiving simultaneous undergraduate and graduate degrees.

**Bachelor of Science in Civil Engineering/Course 1-C**

The 1-C curriculum helps students develop abilities in problem formulation, problem solving, and decision making in civil engineering. Education towards this goal involves learning fundamentals, exercising creativity, and gaining hands-on experience. Specifically, the program includes subjects dealing with structures, materials, computation, and project evaluation.
### Bachelor of Science in Civil Engineering/Course 1-C

#### General Institute Requirements (GIRs)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences</td>
<td>8</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total GIR Subjects Required for SB Degree**: 17

#### Communication Requirement

The program includes a Communication Requirement of 4 subjects: 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and 2 subjects designated as Communication Intensive in the Major (CI-M).

#### PLUS Departmental Program

<table>
<thead>
<tr>
<th>Subject Name</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject names below are followed by credit units, and by prerequisites if any (corequisites in italics).</td>
<td></td>
</tr>
</tbody>
</table>

**Required Subjects**: 159

**Laboratory**: 12

**Restricted Electives**: 12

**Unrestricted Electives**: 48

**Total Units Beyond the GIRs Required for SB Degree**: 183

Notes: * Alternate prerequisites and corequisites are listed in the subject description.

For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, [http://student.mit.edu/catalog/index.cgi](http://student.mit.edu/catalog/index.cgi).

### Bachelor of Science in Environmental Engineering Science/Course 1-E

The 1-E option is designed for students who wish to gain an in-depth understanding of the physical, chemical, and biological processes that control natural and engineered environments and their interactions with human activities. Subjects in environmental transport and hydrology share a laboratory that emphasizes both practical skills and the use of measurements to test hypotheses. Similarly, the environmental chemistry and biology subjects are accompanied by a laboratory that introduces methods for relevant measurements in ecosystems and engineered systems. Unrestricted electives and advanced restricted electives are typically used to build depth in particular areas of interest to the student.

The 1-E program provides the education necessary for careers in environmental engineering and science, as well as in many other fields. It also provides a solid foundation for graduate studies, which is designed to further develop the professional engineering skills of Course 1-C students. This program is ABET accredited.

### Bachelor of Science as Recommended by the Department of Civil and Environmental Engineering/Course 1-A

The degree of Bachelor of Science as recommended by the Department of Civil and Environmental Engineering (Course 1-A) is provided for those students who are drawn to the core features of our curriculum but want to design individualized programs to meet particular educational objectives. For example, a student...
interested in medicine may need more room in the curriculum in order to complete all the subjects required for medical school admission. Other students interested in research careers in fields such as microbiology, geochemistry, oceanography, or environmental law may want more time for advanced subjects in those fields. Such students may benefit from a Civil and Environmental Engineering 1-A degree, since they do not need ABET accreditation but do need flexibility. Students should speak with a faculty advisor about the advantages and limitations of a 1-A degree before making a final decision.

There are seven required 1-A subjects that coincide with the sophomore core of the 1-C and 1-E programs. In addition, 1-A students must select a coherent set of seven electives that meet a well-defined educational goal (e.g. a premedical sequence). The planned electives are developed in consultation with and are approved by a member of the departmental faculty who serves as the student’s academic advisor. Planned electives may be selected from subjects within the Department of Civil and Environmental Engineering or outside the department. In addition, students may write an undergraduate thesis in lieu of one or more of the planned electives. To satisfy the CI-M component of the Communication Requirement, students must take the department’s two CI-M subjects (1.013 and 1.018) or, if appropriate, take one Course 1 CI-M subject and petition the Subcommittee on the Communication Requirement to substitute one CI-M from another science or engineering field. The outside CI-M must fit into the coherent program of electives approved by the student’s academic advisor. The remaining part of the 1-A program consists of unrestricted electives to bring the total to 180 units beyond the General Institute Requirements.

Undergraduate Summer Internship Program

Sophomores and juniors majoring in civil and environmental engineering may apply to participate in the Undergraduate Summer Internship Program, coordinated by the Department of Civil and Environmental Engineering. The internship program helps MIT students find summer employment opportunities with companies and agencies engaged in civil and environmental engineering. For more information and a partial

<table>
<thead>
<tr>
<th>Bachelor of Science in Environmental Engineering Science/Course 1-E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Institute Requirements (GIRs)</strong></td>
</tr>
<tr>
<td><strong>Science Requirement</strong></td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement [one subject can be satisfied by 1.001, 1.002, or 14.01 in the Departmental Program]</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement [can be satisfied by 1.018J, 1.050, and 18.03 in the Departmental Program]</td>
</tr>
<tr>
<td>Laboratory Requirement [can be satisfied by 1.001 and 1.002 in the Departmental Program]</td>
</tr>
<tr>
<td><strong>Total GIR Subjects Required for SB Degree</strong></td>
</tr>
<tr>
<td><strong>Communication Requirement</strong></td>
</tr>
<tr>
<td>The program includes a Communication Requirement of 4 subjects:</td>
</tr>
<tr>
<td>2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and</td>
</tr>
<tr>
<td>2 subjects designated as Communication Intensive in the Major (CI-M).</td>
</tr>
<tr>
<td><strong>Required Subjects</strong></td>
</tr>
<tr>
<td>1.013 Introduction to Civil and Environmental Engineering Design I, 6, 1/2 LAB; 1.018</td>
</tr>
<tr>
<td>1.018 Introduction to Civil and Environmental Engineering Design II, 6, 1/2 LAB</td>
</tr>
<tr>
<td>1.050 Environmental Chemistry and Biology, 12; 1.061, Chemistry (GIR), Biology (GIR)</td>
</tr>
<tr>
<td>1.060 Introduction to Hydrology, 12; 1.061, 1.106</td>
</tr>
<tr>
<td>1.061 Environmental Fluid Transport Processes and Hydrology Laboratory, 6, 1/2 LAB; 1.061, 1.070</td>
</tr>
<tr>
<td>1.064 Physical Limnology, 12; 1.063</td>
</tr>
<tr>
<td>1.070 Environmental Chemistry and Biology Laboratory, 6, 1/2 LAB; 1.080</td>
</tr>
<tr>
<td>1.071 Global Change Science, 12; 18.03</td>
</tr>
<tr>
<td>1.072 Groundwater Hydrology, 12; 1.061</td>
</tr>
<tr>
<td>1.080 Environmental Chemistry, 12; Chemistry (GIR)</td>
</tr>
<tr>
<td>1.083 Environmental Health Engineering and Biology, 12; 1.061, Chemistry (GIR), Biology (GIR)</td>
</tr>
<tr>
<td>1.085 Air Pollution, 12; 18.03</td>
</tr>
<tr>
<td>1.089 Environmental Microbiology, 12; Biology (GIR)</td>
</tr>
<tr>
<td>1.090 Thermodynamics and Kinetics, 12; REST; Chemistry (GIR), Calculus II (GIR)</td>
</tr>
<tr>
<td><strong>Restricted Elective</strong></td>
</tr>
<tr>
<td>1.013 Introduction to Civil and Environmental Engineering Design I, 6, 1/2 LAB; 1.018, 1.050</td>
</tr>
<tr>
<td>1.020 Engineering Mechanics II, 12; permission of instructor*</td>
</tr>
<tr>
<td>1.050 Engineering Mechanics I, 12, REST; Physics I (GIR), Calculus II (GIR)</td>
</tr>
<tr>
<td>1.061 Environmental Fluid Transport Processes and Hydrology Laboratory, 6, 1/2 LAB; 1.061, 1.070</td>
</tr>
<tr>
<td>1.070 Environmental Chemistry and Biology Laboratory, 6, 1/2 LAB; 1.080</td>
</tr>
<tr>
<td>1.071 Global Change Science, 12; 18.03</td>
</tr>
<tr>
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<tr>
<td>1.080 Environmental Chemistry, 12; Chemistry (GIR)</td>
</tr>
<tr>
<td>1.083 Environmental Health Engineering and Biology, 12; 1.061, Chemistry (GIR), Biology (GIR)</td>
</tr>
<tr>
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</tr>
<tr>
<td>1.089 Environmental Microbiology, 12; Biology (GIR)</td>
</tr>
<tr>
<td>1.090 Thermodynamics and Kinetics, 12; REST; Chemistry (GIR), Calculus II (GIR)</td>
</tr>
<tr>
<td><strong>Economics and Public Policy</strong></td>
</tr>
<tr>
<td>One of the following three subjects:</td>
</tr>
<tr>
<td>1.000 Uncertainty in Engineering, 12; Calculus I (GIR)</td>
</tr>
<tr>
<td>1.001 Introduction to Computers and Engineering Problem Solving, 12, REST; Calculus I (GIR)</td>
</tr>
<tr>
<td>1.012 Engineering Mechanics I, 12; permission of instructor*</td>
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<td><strong>Laboratory</strong></td>
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</tr>
<tr>
<td>1.070 Environmental Chemistry and Biology Laboratory, 6, 1/2 LAB; 1.080</td>
</tr>
<tr>
<td><strong>Total Units Beyond the GIRs Required for SB Degree</strong></td>
</tr>
<tr>
<td><strong>Unrestricted Electives</strong></td>
</tr>
<tr>
<td><strong>Notes</strong></td>
</tr>
<tr>
<td>* Alternate prerequisites and corequisites are listed in the subject description.</td>
</tr>
<tr>
<td>(i) Any of the subjects that fulfill the Institute Chemistry Requirement is satisfactory, though 5.111 or 5.112 is recommended.</td>
</tr>
<tr>
<td>(ii) Students are encouraged to take both 1.00 and 1.010, in which case one may be counted as a restricted elective.</td>
</tr>
<tr>
<td>For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing &amp; Schedule, <a href="http://student.mit.edu/catalog/index.cgi">http://student.mit.edu/catalog/index.cgi</a>.</td>
</tr>
</tbody>
</table>
**Bachelor of Science as Recommended by the Department of Civil and Environmental Engineering/Course 1-A**

<table>
<thead>
<tr>
<th>General Institute Requirements (GIRs)</th>
<th>Subjects</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement (REST)</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>2</td>
<td>(can be satisfied by 1.018, 1.050, and 18.03 in the Departmental Program)</td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>1</td>
<td>(can be satisfied by 1.101 and 1.102 in the Departmental Program)</td>
</tr>
</tbody>
</table>

**Total GIR Subjects Required for SB Degree**

<table>
<thead>
<tr>
<th>Departmental Program Units That Also Satisfy the GIRs</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Subjects</td>
<td>84</td>
</tr>
<tr>
<td>Core</td>
<td></td>
</tr>
<tr>
<td>1.018 Ecology I: The Earth System, 12, REST, CI-M</td>
<td></td>
</tr>
<tr>
<td>1.020 Ecology II: Engineering for Sustainability, 12, Physics I (GIR), 18.03*</td>
<td></td>
</tr>
<tr>
<td>1.050 Engineering Mechanics I, 12, REST, Physics I (GIR), Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td>1.060 Engineering Mechanics II, 12; permission of instructor*</td>
<td></td>
</tr>
<tr>
<td>18.03 Differential Equations, 12, REST; Calculus II (GIR)</td>
<td></td>
</tr>
</tbody>
</table>

One of the following two subjects:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000 Introduction to Computers and Engineering Problem Solving, 12, REST; Calculus I (GIR)</td>
<td></td>
</tr>
<tr>
<td>1.020 Uncertainty in Engineering, 12; Calculus II (GIR)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laboratory</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.101 Introduction to Civil and Environmental Engineering Design I, 6, 1/2 LAB; 1.018, 1.050</td>
<td></td>
</tr>
<tr>
<td>1.102 Introduction to Civil and Environmental Engineering Design II, 6, 1/2 LAB; 1.060, permission of instructor</td>
<td></td>
</tr>
</tbody>
</table>

**Restrictive Electives**

Students are required to take a coherent set of seven full subjects that meet a well-defined educational goal. These electives may be from within or outside the Department of Civil and Environmental Engineering. Students must provide a clear rationale for their elective choices, which must be approved by their academic advisors and the undergraduate officer of the department.

**Total Units Beyond the GIRs Required for SB Degree**

<table>
<thead>
<tr>
<th>Unrestricted Electives</th>
<th>48</th>
</tr>
</thead>
</table>

**Notes**

* Alternate prerequisites and corequisites are listed in the subject description.

**Undergraduate Practice Opportunities Program**

The Undergraduate Practice Opportunities Program (UPOP) is a full-year co-curricular program that focuses on the knowledge, tools, and analytic frameworks students need to effectively translate their classroom training in science, math, and engineering into thriving leadership careers of their own design. UPOP is a School of Engineering program open to all sophomores, regardless of major. UPOP provides students with academic training, practical experience, networking opportunities, and mentor relationships, along with individually tailored coaching and team challenge activities. With guidance from MIT faculty, UPOP staff, and industry professionals, students obtain meaningful summer internships in commercial, government, and nonprofit sectors in the US and abroad. UPOP’s 6-unit curriculum serves as the foundational year of the Bernard M. Gordon-MIT Engineering Leadership Program. Further information is available from the department in which the student is registered; from Susann Luperfoy, executive director, Undergraduate Practice Opportunities Program, Room 12-193, 617-253-0055, mobile 617-921-3931, luperfoy@mit.edu, upop@mit.edu; or from http://upop.mit.edu/.

**Electives and Research Opportunities**

A list of undergraduate electives in civil and environmental engineering may be obtained from the department http://cee.mit.edu/undergraduate/courses/. Students registered in the department are encouraged to consider appropriate subjects offered by other departments as part of their elective programs.

Students wishing to work closely with a member of the faculty on research may obtain permission to register for thesis, or to enroll in 1.999 Undergraduate Studies in Civil and Environmental Engineering. Numerous possibilities for UROP projects exist in the department, and several UROP traineeships are awarded to undergraduates each spring.
Minors

The Minor in Civil Engineering consists of the following subjects:

1.050 Engineering Mechanics I
1.060 Engineering Mechanics II
1.101 Introduction to Civil and Environmental Engineering Design I
1.102 Introduction to Civil and Environmental Engineering Design II
1.035 Mechanics of Structures and Soils and
1.041 Transportation Systems Modeling or
1.036 Structural and Geotechnical Engineering Design

The Minor in Environmental Engineering Science consists of the following subjects:

1.018 Ecology I: The Earth System
1.020 Ecology II: Engineering for Sustainability
1.101 Introduction to Civil and Environmental Engineering Design I
1.102 Introduction to Civil and Environmental Engineering Design II
1.080 Environmental Chemistry
1.107 Environmental Chemistry and Biology Laboratory and one of the following three subjects:
1.80J Environmental Law, Policy, and Economics: Pollution Prevention and Control
11.002J Making Public Policy
14.01 Principles of Microeconomics

Substitution of equivalent subjects offered by other departments is allowed, with permission of the minor advisor. However, at least three full subjects (12 units) must be Course 1 subjects.

For a general description of the minor program, see Undergraduate Education in Part 1.

Graduate Study

The Department of Civil and Environmental Engineering grants the following advanced degrees: Master of Engineering in Civil and Environmental Engineering, Master of Science in Transportation, Master of Science, Master of Science in Civil and Environmental Engineering, Civil Engineer, Doctor of Science, and Doctor of Philosophy. The Institute’s general requirements for these degrees are described under Graduate Education in Part 1. Detailed information on the departmental requirements for each degree may be obtained from the Academic Programs Office, Room 1-290.

Master of Engineering

The Department of Civil and Environmental Engineering’s Master of Engineering (MEng) is a nine-month program that provides a practice-oriented education with a focus on real-world engineering challenges. It is designed for people with a bachelor’s degree in engineering (or related field) who want to enter or return to professional practice. Our graduates routinely join leading engineering design firms, consulting companies, and government agencies. Some go on to pursue a PhD. The distinctive element of the program is a professional practice experience comprising a group project and an individual, practice-oriented thesis.

MEng students specialize in one of four tracks: environmental and water quality engineering, geotechnology, high-performance structures, or transportation.

All students, independent of specialty area, take 1.133 Concepts of Engineering Practice, during the fall term. In this subject, students work in teams to develop and present solutions to realistic professional problems, which include project management and evaluation, negotiation, business development, and ethics. In addition, each specialty area has three suggested core subjects, two planned electives, and one free elective.

Because of their intensive coursework, MEng students do not have time to work as full-time research or teaching assistants. Some engage in part-time work, but we urge caution as this can drain time away from academic work. A limited number of partial-tuition fellowships are awarded on a merit basis.

Admission standards are the same as for the Master of Science degree. Strong communication skills are expected. MIT undergraduates may apply to the program at the end of their third year.

For more information, see the Master of Engineering program description on the department’s website at http://cee.mit.edu/.

Master of Science and Doctoral Degrees

Programs of graduate study are available in the following areas: environmental chemistry, environmental fluid mechanics and coastal engineering, environmental microbiology, geotechnical engineering and geomechanics, hydrology and hydroclimatology, the mechanics of materials and structures, and transportation.

The program in environmental chemistry focuses on processes governing chemical fates in the natural environment and in engineered systems. Quantitative mass balances are commonly sought using measurements made in controlled laboratory experiments as well as in environmental settings. An understanding of the mechanisms that regulate the cycling of materials through natural and man-made ecosystems is essential to address and avoid environmental problems. Air, water, sediments, soils, and biota are all targets of the work seeking to understand the effects of natural and anthropogenic chemicals that may have toxic effects.

Environmental fluid mechanics and coastal engineering considers the physical processes associated with water and water motion that are essential to the understanding, protection, and improvement of the environment. The program includes theoretical, numerical, experimental, and field studies, which range in scale from the swimming of microorganisms to the transport of carbon dioxide through the global ocean basin. While rooted in the fundamental analyses of fluid physics, our projects are guided by practical problems in environmental science such as the protection of coastal water quality, the prediction and mitigation of coastal erosion, and the restoration of channels and coastal zones.

Environmental microbiology focuses on microbial properties and processes that define the structure and function of natural and man-made ecosystems. Water is a key medium through which energy and elements are transported within and between ecosystems, and it is also a conduit for the transport of anthropogenic materials and waste. Because microorganisms are the primary living constituents of aquatic ecosystems and mediate globally important processes, we focus on environmental microbiology. Our studies are grounded in microbial physiology, ecology, evolution and environmental science and engineering. This program emphasizes PhD-level research.
Geotechnical engineering and geomechanics addresses a wide range of problems posed by the spatial variability and complex material properties of soils and rocks. Geotechnical engineers have historically dealt with natural hazards from landslides to earthquakes, and the design and construction of major infrastructure projects ranging from earth dams to offshore structures. Geoenvironmental problems of subsurface waste containment, groundwater contamination and site remediation are now also a major focus of the profession, as are problems related to resource extraction, including engineered geothermal systems. The graduate program includes core subjects in soil mechanics; engineering geology and groundwater hydrology; application subjects involving geotechnical and geoenvironmental problems; and specialized subjects in geomaterial (soil and rock) behavior, theoretical and experimental methods, and underground construction.

Graduate study in hydrology and hydroclimatology considers all aspects of the hydrologic cycle, with an emphasis on better understanding the physical, chemical and biological processes associated with the movement of water. Our goal is to give students the knowledge they need to address important environmental and resource challenges and to develop informed solutions that improve quality of life. Hydrologic education and research are inherently multidisciplinary and typically involve integration of theory, data analysis, and modeling. Students develop expertise in the basic sciences, applied mathematics and, depending on their research topic, in laboratory and field research, mathematical modeling, economics, and public policy. This program emphasizes PhD-level research.

The graduate program in the mechanics of materials and structures emphasizes fundamental understanding of, and innovative approaches to, structural engineering problems. This includes assessing and upgrading aging infrastructure, developing and using better construction materials, and designing for increased performance by improving safety, lowering costs, and reducing the impact on the environment. The program also emphasizes the mechanical behavior of construction materials and mechanics of materials at scales ranging from nano to macro, relating the continuum scale to the atomistic scale.

Graduate study in transportation examines all major forms of transportation, including passenger and freight systems, as well as the increasing demand for transportation systems at the local, regional and international levels. Projects and coursework consider the critical issues involved in meeting transportation needs in a sustainable way. The Transportation program in CEE emphasizes the complexity of transportation and its dependence on the interaction of technology, operations, planning, management, and policy making. Our focus includes study of the interactions of transportation infrastructure and operations, urban spatial structure and land use, economic growth, resource and energy use, and environmental impacts at various spatial and temporal scales.

Entrance Requirements for Graduate Study
The primary requirements for graduate study are a strong intellect and the ability and interest to pursue rigorous, focused study. Applicants do not need an undergraduate degree in civil engineering. For students with backgrounds in other branches of engineering, science, and certain social sciences, numerous research opportunities exist for interdisciplinary research that brings people of complementary backgrounds together in search of solutions to major societal problems. For example, graduate students and faculty in the department have experience in geology, chemistry, physics, biology, computer science, economics, political science, sociology, architecture, urban and regional planning, and management.

All applicants are required to submit scores from the GRE Aptitude Test. With some exceptions, applicants whose first language is not English are required to submit scores from either the International English Language Testing System (IELTS), the preferred exam, or the Test of English as a Foreign Language (TOEFL). More information about individual graduate programs can be obtained at [http://cee.mit.edu/](http://cee.mit.edu/) or by writing to cee-admissions@mit.edu.

Financial Assistance
The research of the department is an integral part of the graduate program, and approximately 150 graduate students each year receive appointments as research or teaching assistants. Most of these appointments fully cover tuition, individual health insurance, and reasonable living expenses in the Boston area.

Applicants are encouraged to apply for traineeships and fellowships offered nationally by the National Science Foundation, NASA, DOE, and other governmental agencies that traditionally support students in the department. For an extensive list of such opportunities, visit the Office of the Dean for Graduate Education website, [http://web.mit.edu/odge/](http://web.mit.edu/odge/).

Interdisciplinary Programs
Through its interdisciplinary programs, the Department of Civil and Environmental Engineering brings together the science, technology, systems, and management skills necessary to deal with the important engineering problems of the future.

Graduate Programs in Transportation
MIT provides a broad range of opportunities for transportation-related education. Courses and classes span the School of Engineering, the Sloan School of Management, and the School of Architecture and Planning, with many activities covering interdisciplinary topics that prepare students for future industry, government, or academic careers.

A variety of graduate degrees are available to students interested in transportation studies and research, including a Master of Science in Transportation and PhD in Transportation, described under Interdisciplinary Graduate Programs in Part 3.

Leaders for Global Operations Program
The 24-month Leaders for Global Operations (LGO) program combines graduate education in engineering and management for those with two or more years of full-time work experience who aspire to leadership positions in manufacturing or operations companies. A required six-month internship comprising a research project at one of LGO’s partner companies leads to a dual-degree thesis, culminating in two master’s degrees—an MBA (or SM in management) and an SM from Aeronautics and Astronautics. The program is offered jointly through the MIT Sloan School of Management and the School of Engineering. For more information, visit [http://lgo.mit.edu/](http://lgo.mit.edu/) or see the program description under Engineering Systems Division.

COURSE 1 CIVIL AND ENVIRONMENTAL ENGINEERING
Joint Program with the Woods Hole Oceanographic Institution
The Joint Program with the Woods Hole Oceanographic Institution is intended for students whose primary career objectives are in the field of oceanography or oceanographic engineering. The program is described under Interdisciplinary Graduate Programs in Part 3.

Inquiries
Detailed information about the academic policies and programs of the department may be obtained by writing to or visiting the Academic Programs Office, Room 1-290, 617-253-9723, cee-apo@mit.edu, http://cee.mit.edu/.

Research Laboratories and Activities
The Department of Civil and Environmental Engineering occupies two buildings on the MIT campus: Building 1 (the Pierce Laboratory) and Building 48 (the Ralph M. Parsons Laboratory for Environmental Science and Engineering). These buildings contain specialized research and teaching facilities. In addition, the department collaborates interdepartmentally with other laboratories described below.

Ralph M. Parsons Laboratory for Environmental Science and Engineering
Located on the east campus, the Ralph M. Parsons Laboratory for Environmental Science and Engineering is a four-story structure containing about 31,000 square feet of classrooms, teaching and research laboratories, machine shops, computer facilities, and offices. Approximately 18 faculty members, 74 graduate students, and 35 postdocs have offices on the premises. Facilities exist for hydrodynamic studies involving flow through vegetation, free surface flows, and flows in porous media. The latest in laser-Doppler instrumentation is available. Complete and modern laboratories facilitate research in inorganic chemistry, organic chemistry, molecular biology, genomics, microbial ecology, and biochemistry. Especially notable instrumentation includes several gas chromatographs, three atomic absorption spectrophotometers (two flame and one graphite furnace), alpha and gamma spectrometry counting systems, scintillation counters, several flow cytometers, a laser light scattering instrument, and walk-in incubators and cold room, as well as several -80°C freezers. One laboratory, recently renovated, is a dedicated teaching facility for fluid mechanics, hydrology, aquatic chemistry, and biology. Equipment is available for instruction in a wide range of field sampling methods, biological and microbiological evaluations, and instrumental chemical analyses of natural waters. In addition to a recent acquisition of a two-channel auto analyzer, two state-of-the-art analytical instruments have been purchased for the student laboratory: an inductively coupled plasma mass spectrometer and a gas chromatographic mass spectrometer. Students also have access to several parallel computing clusters in house and across campus.

Pierce Laboratory
Located in one of MIT’s original buildings, this civil and environmental engineering facility overlooks the Charles River and includes over 40,000 square feet of classrooms, teaching and research laboratories, and offices for approximately 100 graduate students and 32 faculty members and research staff.

Research activities focus on two major areas: mechanics and transportation. Among the classrooms is the state-of-the-art Bechtel Lecture Hall. The facilities include a recently renovated undergraduate teaching/project laboratory and common room and a materials testing laboratory. The laboratory has a machine shop, electronics room, 3-D printer, and laser cutter, providing support technology to process, fabricate, and create prototype devices and specimens, test under various stress and environmental conditions, and investigate physical properties. The materials testing laboratory contains several automated universal test frames, a biaxial loading system, and an environmentally controlled nano-indentation system. The geotechnical laboratories combine a broad range of equipment, from conventional to state-of-the-art to specialty research devices. Capabilities and equipment include industrial radiography; centralized data acquisition; computer-automated consolidation, triaxial and high-pressure triaxial cells; simple shear devices; a hollow cylinder apparatus, and a medium-sized centrifuge.

The Pierce Laboratory offers diverse and advanced computational facilities, including network servers and publicly available Windows workstations. The computing facilities feature various structural, project management, geotechnical, and materials analysis software such as SAP, STRUDL, PLAXIS, MATLAB, AUTOCADE, FORTRAN, Primavera, Crystal Ball, ADINA, GaBi, KeyCreator and ABAQUS, and more. Printers and scanners are also present in all clusters in the building.

Concrete Sustainability Hub
The mission of the Concrete Sustainability Hub (CSH) is to advance the technology transfer from concrete science into engineering practice, by translating the synergy of three fields of study into a powerful hub for concrete sustainability studies relevant to industry and decision makers. CSH fosters a close alliance among academia, industry, and government to facilitate the transfer of knowledge by aligning world-leading research with end-user needs.

More concrete is produced than any other synthetic material on Earth. In the foreseeable future there is no other material that can replace concrete to meet our societies’ legitimate needs for housing, shelter, schools, infrastructure, etc. But concrete faces an uncertain future due to a non-negligible ecological footprint that amounts to 5–10 percent of worldwide CO2 production.

Emerging breakthroughs in concrete science and engineering hold the promise that concrete can be part of the solution to contributing to sustainable development that encompasses economic growth, and social progress while minimizing the ecological footprint. This requires a holistic approach in which progress in concrete science seamlessly feeds into innovative structural concrete engineering applications, ranging from concrete pavement solutions to wall systems, whose impact on sustainable development are evaluated with advanced environmental-econometric impact studies. This is the focus of CSH. With this in mind, an exceptional team of dedicated interdisciplinary faculty from three schools within MIT—Engineering, Architecture and Planning, and the Sloan School of Management—are participating. More information is available at http://web.mit.edu/cshub/, or contact CSHub@mit.edu.
Center for Environmental Sensing and Modeling
The Center for Environmental Sensing and Modeling is a collaborative research program within the Singapore-MIT Alliance for Research and Technology involving many faculty members from MIT departments, scholars, and universities. Researchers primarily from MIT and universities in Singapore are developing pervasive environmental sensor networks to collect data from many sources on parameters such as air and water quality. They plan to use this data to provide accurate, real-time monitoring, modeling and control of the environment from the microscale of a building to the macroscale of, for example, East Asia. More information about the center is available at http://smart.mit.edu/research/censam/censam.html.

Earth System Initiative
The Earth System Initiative (ESI) fosters exploration of the intimately interrelated physical, chemical, biological, and geological processes that shape our global ecosystem. By involving faculty, staff, and students across the spectrum of environmentally oriented disciplines, ESI brings the widest variety of scientific perspectives and methods to bear in understanding how the Earth system functions and how we can be better stewards of our planet. For more information, see http://web.mit.edu/esi/.

Center for Global Change Science
The Center for Global Change Science (CGCS) addresses fundamental questions about the environment and climate processes with a multidisciplinary approach. The center’s goal is to improve the ability to accurately predict changes in the global environment. It seeks to better understand the natural mechanisms in ocean, atmosphere, and land systems that together control the Earth’s climate, and to apply improved knowledge to problems of predicting climate changes. The center utilizes theory, observations, and numerical models to investigate climate phenomena, and focuses on large projects that require the cooperation of multiple investigators and disciplines. It provides opportunities for close cooperation in education and research between faculty, research scientist staff, and students in Civil and Environmental Engineering, the Department of Earth, Atmospheric and Planetary Sciences, the MIT Energy Initiative, and other departments. The major projects in CGCS are the Climate Modeling Initiative, the Advanced Global Atmospheric Gases Experiment, and the Joint Program on the Science and Policy of Global Change. More information is available under Interdisciplinary Research and Study in Part 3 or at http://cgcs.mit.edu.

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Andrew J. Whittle, PhD
Edmund K. Turner Professor of Civil and Environmental Engineering
Department Head

Professors
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Ford Professor of Civil and Environmental Engineering and Engineering Systems
Associate Dean for Academic Affairs, School of Engineering
Moshe Emanuel Ben-Akiva, PhD
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Oral Buyukozturk, PhD
Professor of Civil and Environmental Engineering
Sallie W. Chisholm, PhD
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Professor of Civil and Environmental Engineering and Biology
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Martin F. Polz, PhD
Professor of Civil and Environmental Engineering
<table>
<thead>
<tr>
<th>Associate Professors</th>
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<tbody>
<tr>
<td>Markus J. Buehler, PhD</td>
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<tr>
<td>Associate Professor of Civil and Environmental Engineering</td>
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<tr>
<td>Ruben Juanes, PhD</td>
</tr>
<tr>
<td>Atlantic Richfield Career Development Associate</td>
</tr>
<tr>
<td>Professor of Civil and Environmental Engineering</td>
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<tr>
<td>John A. Ochsendorf, PhD</td>
</tr>
<tr>
<td>Associate Professor of Building Technology and Civil and Environmental Engineering</td>
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<tr>
<td>Roman Stocker, PhD</td>
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<tr>
<td>Associate Professor of Civil and Environmental Engineering</td>
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<tr>
<td>Assistant Professors</td>
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<tr>
<td>Eric J. Alm, PhD</td>
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<tr>
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<tr>
<td>Marta C. Gonzalez, PhD</td>
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<td>Carolina Osorio, PhD</td>
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<tr>
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<tr>
<td>Assistant Professor of Civil and Environmental Engineering</td>
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<tr>
<td>Janelle R. Thompson, PhD</td>
</tr>
<tr>
<td>Henry L. and Grace Doherty Assistant Professor of Civil and Environmental Engineering</td>
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<tr>
<td>Senior Lecturers</td>
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<tr>
<td>E. Eric Adams, PhD</td>
</tr>
<tr>
<td>John T. Germaine, PhD</td>
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<tr>
<td>George Kocur, PhD</td>
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<td>Susan Murcott, MS</td>
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<td>Frederick P. Salvucci, MS</td>
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<td>Lecturers</td>
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<td>Charles C. Caldart, JD</td>
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<tr>
<td>Christopher Cassa, PhD</td>
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<td>Sheila Frankel, MA</td>
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<td>V. Judson Harward, PhD</td>
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<td>Lucy Jen, PhD</td>
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<td>Paul Kassabian, MS</td>
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<td>David Langseth, PhD</td>
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<td>Mikel Murga, MS</td>
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<tr>
<td>Erik A. Nelson, MEng</td>
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<tr>
<td>Lance Neumann</td>
</tr>
<tr>
<td>Research Staff</td>
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<tr>
<td>Senior Research Associate</td>
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<td>John T. Germaine, PhD</td>
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<td>E. Eric Adams, PhD</td>
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<td>Senior Research Scientist</td>
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<td>Roland Pellenq, PhD</td>
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<td>Principal Research Engineer</td>
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<tr>
<td>Earle Williams, PhD</td>
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<td>John P. Attanucci, SM</td>
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<td>John MacFarlane, SM</td>
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<td>Research Scientists</td>
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<tr>
<td>Asunción Martínez, PhD</td>
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<tr>
<td>Rafal Wocik, PhD</td>
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<tr>
<td>Rafael Luis Bras, ScD</td>
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<tr>
<td>Professor of Civil and Environmental Engineering, Emeritus</td>
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<tr>
<td>Peter Sturges Eagleson, ScD</td>
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<td>Robert Joseph Hansen, ScD</td>
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<tr>
<td>Professor of Civil and Environmental Engineering, Emeritus</td>
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<td>Charles Cushing Ladd, ScD</td>
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<td>Edmund K. Turner Professor of Civil and Environmental Engineering, Emeritus</td>
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<td>Thomas William Lambe, ScD</td>
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<td>Edmund K. Turner Professor of Civil and Environmental Engineering, Emeritus</td>
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<td>Robert Daniel Logcher, ScD</td>
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<tr>
<td>David Hunter Marks, PhD</td>
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<tr>
<td>Morton and Claire Goulder Family Professor</td>
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<tr>
<td>Professor of Civil and Environmental Engineering and Engineering Systems, Emeritus</td>
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<tr>
<td>Chiang Chung Mei, PhD</td>
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<tr>
<td>Ford Professor of Civil and Environmental Engineering, Emeritus</td>
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<tr>
<td>Frank Edward Perkins, ScD</td>
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<tr>
<td>Professor of Civil and Environmental Engineering, Emeritus</td>
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<tr>
<td>Daniel Roos, PhD</td>
</tr>
<tr>
<td>Professor of Engineering Systems and Civil and Environmental Engineering, Emeritus</td>
</tr>
</tbody>
</table>
Electrical engineers and computer scientists are everywhere—in industry and research areas as diverse as computer and communication networks, electronic circuits and systems, lasers and photonics, semiconductor and solid-state devices, nanoelectronics, biomedical engineering, computational biology, artificial intelligence, robotics, design and manufacturing, control and optimization, computer algorithms, games and graphics, software engineering, computer architecture, cryptography and computer security, power and energy systems, financial analysis, and many more. The infrastructure and fabric of the information age, including technologies such as the internet and the web, search engines, cell phones, high-definition television, and magnetic resonance imaging, are largely the result of innovations in electrical engineering and computer science. The Department of Electrical Engineering and Computer Science at MIT and its graduates have been at the forefront of a great many of these advances. Current work in the department holds promise of continuing this record of innovation and leadership, in both research and education, across the full spectrum of departmental activity.

The career paths and opportunities for EECS graduates cover a wide range and continue to grow: fundamental technologies, devices, and systems based on electrical engineering and computer science are pervasive and essential to improving the lives of people around the world and managing the environments they live in. The basis for the success of EECS graduates is a deep education in engineering principles, built on mathematical, computational, physical, and life sciences, and exercised with practical applications and project experiences in a breadth of areas. Our graduates have also demonstrated over the years that EECS provides a strong foundation for those whose work and careers develop in areas quite removed from their origins in engineering.

Undergraduate students in the department take two core subjects that introduce electrical engineering and computer science, and then systematically build up broad foundations and depth in selected intellectual theme areas that match their individual interests. Laboratory subjects, independent projects, and research provide engagement with principles and techniques of analysis, design, and experimentation in a variety of fields. The department also offers a range of programs that enable students to gain experience in industrial settings, ranging from collaborative industrial projects done on campus to term-long experiences at partner companies.

Graduate study in the department moves students toward mastery of areas of individual interest, through coursework and significant research, often defined in interdisciplinary areas that take advantage of the tremendous range of faculty expertise in the department and, more broadly, across MIT.

More information about the Department of Electrical Engineering and Computer Science and its programs can be obtained from the department’s website at http://www-eecs.mit.edu/.

PROFESSIONAL AND PREPROFESSIONAL PROGRAMS

For MIT undergraduates, the Department of Electrical Engineering and Computer Science offers programs leading to the Bachelor of Science and the Master of Engineering degrees. Three accredited preprofessional four-year Bachelor of Science programs are available. One (6-1) is for students specializing in electrical science and engineering, a second (6-3) for those specializing in computer science and engineering, and a third (6-2) for those whose interests cross this traditional boundary. For interested and qualified students, the master’s program (6-P) leads directly, through a seamless five-year course of study, to the simultaneous awarding of the Master of Engineering and one of the three bachelor’s degrees. The 6-P program is intended to provide the depth of knowledge and the skills needed for advanced graduate study and for professional work, as well as the breadth and perspective essential for engineering leadership in an increasingly complex technological world.

The 6-A Master of Engineering Thesis Program with Industry combines the professional Master of Engineering academic program with periods of industrial practice at affiliated companies. An undergraduate wishing to pursue the Master of Engineering degree should initially register for one of the three bachelor’s programs.

The bachelor’s programs build on the General Institute Requirements in science and the humanities, and are structured to provide early, hands-on engagement with ideas, activities, and learning that allow students to experience the range and power of electrical engineering and computer science in an integrated way. The required introductory core subjects, 6.01 followed by 6.02, both involve substantial work in the laboratory, and each carries six units of Institute Lab credit. These are complemented by two mathematics subjects (6.041 or 6.042, also 18.03 or 18.06) and followed by a choice of three or four foundation courses (depending on which bachelor’s program is selected) from a set of subjects that provide the basis for subsequent specialization. Students define their specialization by selecting three header subjects, a department laboratory subject, and two advanced undergraduate subjects from a quite extensive set of possibilities, and also carry out an advanced undergraduate project. Combining these with the four free electives permits students considerable latitude in shaping their program to match diverse interests, while ensuring depth and mastery in a few selected areas.

The master’s program provides additional depth in a selected field of concentration, through coursework and a substantial thesis. The student selects (with departmental review and approval) 42 units of advanced graduate (H-level) subjects; these subjects, considered along with the two advanced undergraduate subjects from the bachelor’s program, must include at least 36 units in an area of concentration. A further 24 units of electives are chosen from a restricted departmental list of mathematics, science, and engineering subjects.

The Master of Engineering degree also requires completion of 24 units of thesis credit under 6.ThM. While a student may register for more than this number of thesis units, only 24 units count toward the degree requirement. Theses based on group projects in which each participant has an identified responsibility are encouraged.

Recipients of a Master of Engineering degree normally receive a Bachelor of Science degree simultaneously. No thesis is explicitly required for the preprofessional Bachelor of Science degree. However, every program must include a major project experience at an advanced level, culmi-
Bachelor of Science in Electrical Science and Engineering/Course 6-1
Bachelor of Science in Electrical Engineering and Computer Science/Course 6-2
Bachelor of Science in Computer Science and Engineering/Course 6-3

General Institute Requirements (GIRs)  

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement (satisfied by 6.01 and 6.02 together in the Departmental Program)</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Total GIR Subjects Required for SB Degree</td>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>

Communication Requirement  
The program includes a Communication Requirement of 4 subjects:  
2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and  
2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program  

| Subject names below are followed by credit units and by prerequisites, if any (corequisites in italics). |
|--------------------------------------------------|----------|-------|
| Required Subjects                                |          | 36    |
| 6.01 Introduction to EECS I, 12, 1/2 LAB; Physics II (GIR) |          |       |
| 6.02 Introduction to EECS II, 12, 1/2 LAB; 6.01, 18.03* |          |       |
| 6.11 and 6.14 Undergraduate Advanced Project, 12   |          |       |
| Restricted Electives (also satisfies REST requirement): |          | 132–144 |
| 1. Two mathematics subjects                      |          |       |
| (a) Either 18.03 or 18.06 (alternatively 18.700)   |          |       |
| (b) Either 6.041 (alternatively 8.440) or 6.042    |          |       |
| 2. One department laboratory:                     |          |       |
| One subject selected from the undergraduate laboratory subjects 6.100–6.182 or a departmental list of CS laboratory subjects; students in Course 6-3 must select a CS laboratory subject. Students in Course 6-1 or 6-2 who take both 6.021 and 6.022 may use 6.022 to satisfy the department laboratory requirement. |          |       |
| 3. Three/four foundation subjects:                |          |       |
| (a) Students in Course 6-1 must take three subjects from the EE foundation list: 6.002, 6.003, 6.004, 6.007 |          |       |
| (b) Students in Course 6-3 must take the three subjects in the CS foundation list: 6.004, 6.005, 6.006 |          |       |
| (c) Students in Course 6-2 must take four subjects from the EECS foundation list (6.002–6.007), with two chosen from the EE foundation list and two from the CS foundation list (6.004 may be counted under either EE or CS). |          |       |
| 4. Three header subjects:                         |          |       |
| (a) Students in Course 6-1 must take three subjects from the EE header list: 6.011, 6.012, 6.013, 6.021 |          |       |
| (b) Students in Course 6-3 must take the three subjects in the CS header list: 6.033, 6.034, 6.046 |          |       |
| (c) Students in Course 6-2 must take three subjects from the EECS header list (6.011, 6.012, 6.013, 6.021, 6.033, 6.034, 6.046), with at least one chosen from the EE header list and at least one from the CS header list. |          |       |
| 5. Two subjects from a departmental list of advanced undergraduate subjects. |          |       |
| To complete the required Communication-Intensive subjects in the major, students must take one of the following CI-M subjects as a restricted elective in categories 2 or 4 above by the end of the third year: 6.021, 6.033, 6.101, 6.111, 6.115, 6.131, 6.141, 6.152, 6.161, 6.163, 6.173, 6.182, or 6.805. 6.11 and 6.14 Undergraduate Advanced Project, 12 |          |       |

Departmental Program Units That Also Satisfy the GIRs  

<table>
<thead>
<tr>
<th>Required Subjects</th>
<th>36</th>
</tr>
</thead>
</table>

Unrestricted Electives  

<table>
<thead>
<tr>
<th>Units</th>
</tr>
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<tbody>
<tr>
<td>48</td>
</tr>
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</table>

Total Units Beyond the GIRs Required for SB Degree  

<table>
<thead>
<tr>
<th>Units</th>
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<tbody>
<tr>
<td>180–192</td>
</tr>
</tbody>
</table>

No subject can be counted both as part of the 17-subject GIRs and as part of the 180–192 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

Notes  

* Alternate prerequisites are listed in the subject descriptions.

* See the description of required communication-intensive subjects for information about acceptable substitutions for the 6.11 and 6.14 Undergraduate Advanced Project, 12 sequence.

For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.
program. Support through an assistantship may extend the period required to complete the Master of Engineering program by an additional term or two. Support is granted competitively to graduate students and will not be available for all of those admitted to the Master of Engineering program. If provided, department support for Master of Engineering candidates is normally limited to the first three terms as a graduate student, unless the Master of Engineering thesis has been completed or the student has served as a teaching assistant or has been admitted to the doctoral program, in which cases a fourth term of support may be permitted.

Additional information about the department’s professional and preprofessional programs may be obtained from the EECS Undergraduate Office, Room 38-476, 617-253-7329, ug@eecs.mit.edu.

Bachelor of Science in Computer Science and Molecular Biology/Course 6-7
The Department of Electrical Engineering and Computer Science jointly offers a Bachelor of Science in Computer Science and Molecular Biology with the Department of Biology (Course 7). A detailed description of the list of requirements for this degree program may be found under Interdisciplinary Undergraduate Programs and Minors in Part 3.

6-A Master of Engineering Thesis Program with Industry
The 6-A Master of Engineering Thesis Program with Industry enables students to combine classroom studies with practical experience in industry through a series of supervised work assignments at one of the companies or laboratories participating in the program, culminating with a Master of Engineering thesis performed at a 6-A member company. Collectively, the participating companies provide a wide spectrum of assignments in the various fields of electrical engineering and computer science, as well as an exposure to the kinds of activities in which engineers are currently engaged. Since a continuing liaison between the companies and faculty of the department is maintained, students receive assignments of progressive responsibility and sophistication that are usually more professionally rewarding than typical summer jobs.

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Master of Engineering in Electrical Engineering and Computer Science/Course 6-P
See Notes on Master of Engineering and Bachelor’s Degree Programs (next page)

<table>
<thead>
<tr>
<th>General Institute Requirements (GIRs)</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>8</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement [satisfied by the mathematics requirement in the Departmental Program]</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement [satisfied by 6.01 and 6.02 together in the Departmental Program]</td>
<td>1</td>
</tr>
<tr>
<td>Total GIR Subjects Required for the SB and MEng Degrees</td>
<td>17</td>
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<table>
<thead>
<tr>
<th>Communication Requirement</th>
<th>Units</th>
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</thead>
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<tr>
<td></td>
<td>598–210</td>
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</table>

<table>
<thead>
<tr>
<th>PLUS Department Program</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics)</td>
<td>98–210</td>
</tr>
<tr>
<td>Required Subjects</td>
<td>60</td>
</tr>
<tr>
<td>6.01 Introduction to EEE 1, 12, 1/2 LAB; Physics II (GIR)</td>
<td></td>
</tr>
<tr>
<td>6.02 Introduction to EEE 11, 12, 1/2 LAB; 6.01, 18.03*</td>
<td></td>
</tr>
<tr>
<td>6.UAT and 6.UAP Undergraduate Advanced Project, 12</td>
<td></td>
</tr>
<tr>
<td>6ThM MEng Program Thesis, 24**</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Restricted Electives</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Two mathematics subjects (also satisfies REST requirement):</td>
<td></td>
</tr>
<tr>
<td>(a) Either 18.03 or 18.06 (alternatively 18.700)</td>
<td></td>
</tr>
<tr>
<td>(b) Either 6.04b (or 18.440) or 6.04b</td>
<td></td>
</tr>
<tr>
<td>2. One department laboratory:</td>
<td></td>
</tr>
<tr>
<td>One subject selected from the undergraduate laboratory subjects 6.000-6.182 or a departmental list of CS laboratory subjects; students in Course 6-3 must select a CS laboratory subject. Students in Course 6-1 or 6-2 who take both 6.021J and 6.022J may use 6.022J to satisfy the laboratory department requirement.</td>
<td></td>
</tr>
<tr>
<td>3. Three/four foundation subjects:</td>
<td></td>
</tr>
<tr>
<td>(a) Students in Course 6-1 must take three subjects from the EE foundation list: 6.004, 6.005, 6.006.</td>
<td></td>
</tr>
<tr>
<td>(b) Students in Course 6-3 must take the three subjects in the CS foundation list: 6.004, 6.005, 6.006.</td>
<td></td>
</tr>
<tr>
<td>(c) Students in Course 6-2 must take four subjects from the EECs foundation list (6.002-6.006), with two chosen from the EE foundation list and two from the CS foundation list (6.004 may be counted under either EE or CS).</td>
<td></td>
</tr>
<tr>
<td>4. Three header subjects:</td>
<td></td>
</tr>
<tr>
<td>(a) Students in Course 6-1 must take three subjects from the EE header list: 6.011, 6.012, 6.013, 6.021,</td>
<td></td>
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<tr>
<td>(b) Students in Course 6-3 must take the three subjects in the CS header list: 6.033, 6.034, 6.046.</td>
<td></td>
</tr>
<tr>
<td>(c) Students in Course 6-2 must take three subjects from the EECs header list: 6.011, 6.012, 6.013, 6.021, 6.033, 6.034, 6.046, with at least one chosen from the EE header list and at least one from the CS header list.</td>
<td></td>
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<tr>
<td>5. Two subjects from a departmental list of advanced undergraduate subjects.</td>
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<tr>
<td>6. Four H-level graduate subjects totaling at least 42 units, of which at least 36 units must come from subjects taken within the department.</td>
<td></td>
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<tr>
<td>7. Two subjects from a restricted departmental list of mathematics, science, and engineering electives.</td>
<td></td>
</tr>
<tr>
<td>To complete the required Communication-Intensive subjects in the major, students must take one of the following CI-M subjects as a restricted elective in categories 2 or 4 above by the end of the third year: 6.021J, 6.033, 6.101, 6.111, 6.113, 6.121, 6.122, 6.161, 6.163, 6.173, 6.182, or 6.805.</td>
<td></td>
</tr>
<tr>
<td>8. 6.UAT/6.UAR, typically constitutes the second CI-M. Students may also take 6.UAT plus a second CI-M undergraduate laboratory subject (6.101, 6.111, 6.113, 6.121, 6.122, 6.161, 6.163, 6.173, 6.182) to fulfill the CI-M component of Communication Requirement.</td>
<td></td>
</tr>
</tbody>
</table>

| Departmental Program Units That Also Satisfy the GIRs | (30) |
| Unrestricted Electives | 48 |

Total Units Beyond the GIRs Required for Simultaneous Award of the MEng and SB Degrees 270–282
No subject can be counted both as part of the 17-subject GIRs and as part of the 270–282 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

Notes
*Alternate prerequisites are listed in the subject description.
**6-PA Program requires performance of thesis at company location.
The 6-A program is primarily designed to work in conjunction with the department’s five-year Master of Engineering degree program. Internship students generally complete three assignments with their cooperating company—usually two summers and one regular term. While on 6-A assignment, students receive pay from the participating company as well as academic credit for their work. During their graduate year, 6-A students generally receive a 6-A fellowship or a research or teaching assistantship to help pay for the graduate year.

The department conducts a fall recruitment during which juniors who wish to work toward an industry-based Master of Engineering thesis may apply for admission to the 6-A program. Acceptance of a student into the program cannot be guaranteed, as openings are limited. At the end of their junior year, most 6-A students can expect to gain admission to 6-PA, which is the 6-A version of the department’s five-year 6-P Master of Engineering degree program. 6-PA students do their Master of Engineering thesis at their participating company’s facilities. They can apply up to 36 units of work-assignment credit toward their Master of Engineering degree. Thus, completing the Master of Engineering program need not take longer under 6-PA than under the 6-P program.

The first 6-A assignment may be used for the advanced undergraduate project that is required for award of a bachelor’s degree, by including a written report and obtaining approval by a faculty member.

At the conclusion of their program, 6-A students are not obliged to accept employment with the company, nor is the company obliged to offer such employment.

Additional information about the 6-A Master of Engineering Thesis Program with Industry is available at the 6-A Office, Room 38-409E, 617-253-4644, and on the department website.

DOCTORAL AND PREDOCTORAL PROGRAMS

The programs of education offered by the Department of Electrical Engineering and Computer Science at the doctoral and predoctoral level have three aspects. First, a variety of classroom subjects in physics, mathematics, and fundamental fields of electrical engineering and computer science is provided to permit students to develop strong scientific 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 that may be useful in attacking them. Third, each student 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 in addition to the Master of Engineering program described above. A well-prepared student with a bachelor’s degree in an appropriate field from some school other than MIT (or from another department at MIT) normally requires about one and one-half to two years to complete the formal studies and the required thesis research in the Master of Science degree program. (Students who have been undergraduates in Electrical Engineering and Computer Science at MIT and who seek opportunities for further study must complete the Master of Engineering rather than the Master of Science degree program.) With an additional year of study and research beyond the master’s level, a student in the doctoral or predoctoral program can complete the requirements for the degree of Electrical Engineer or Engineer in Computer Science. The doctoral program usually takes about four to five years beyond the master’s level.

There are no fixed programs of study for these doctoral and predoctoral degrees. Each student plans a program in consultation with a faculty advisor. As the program moves toward thesis research, it usually centers in one of a number of areas, each characterized by an active research program. Areas of specialization in the department that have active research programs and related graduate subjects include communications, control, signal processing, and optimization; computer science; artificial intelligence, robotics, computer vision, and graphics; electronics, computers, systems, and networks; electromagnetics and electrodynamics; optics, photonics, and quantum electronics; energy conversion devices and systems; power engineering and power electronics; materials and devices; VLSI system design and technology; nanoelectronics; bioelectrical engineering; and computational biology.

In addition to graduate subjects in electrical engineering and computer science, many students find it profitable to study subjects in other departments such as Biology, Economics, Linguistics and Philosophy, Management, Mathematics, Physics, and Brain and Cognitive Sciences.

The informal seminar is an important mechanism for bringing together members of the various research groups. Numerous seminars meet every week. In these, graduate students, faculty, and visitors report their research in an atmosphere of free discussion and criticism. These open seminars are excellent places to learn about the various research activities in the department.

Research activities in electrical engineering and computer science are carried on by students and faculty in laboratories of extraordinary range and strength, including the Laboratory...
for Information and Decision Systems, Research Laboratory of Electronics, Computer Science and Artificial Intelligence Laboratory, Center for Materials Science and Engineering, Laboratory for Energy and the Environment (see MIT Energy Initiative), Kavli Institute for Astrophysics and Space Research, Lincoln Laboratory, Media Laboratory, Francis Bitter Magnet Laboratory, Operations Research Center, Plasma Science and Fusion Center, and the Microsystems Technology Laboratories. Descriptions of many of these laboratories may be found under Interdisciplinary Research and Study in Part 3.

Because the backgrounds of applicants to the department’s doctoral and predoctoral programs are extremely varied, both as to field (electrical engineering, computer science, physics, mathematics, biomedical engineering, etc.) and as to level of previous degree (bachelor’s or master’s), no specific admissions requirements are listed. All applicants for any of these advanced programs will be evaluated in terms of their potential for successful completion of the department’s doctoral program. Superior achievement in relevant technical fields is considered particularly important.

Master of Science in Electrical Engineering and Computer Science
The general requirements for the degree of Master of Science are given in Graduate Education in Part 1. The department requires that the 66-unit program consist of at least four H-level subjects which must include a minimum of 42 H-level units. In addition, a 24-unit thesis is required beyond the 66 units. Students working full-time for the Master of Science degree may take as many as four classroom subjects per term. The subjects are wholly elective and are not restricted to those given by the department. The program of study must be well balanced, emphasizing one or more of the theoretical or experimental aspects of electrical engineering or computer science.

Electrical Engineer or Engineer in Computer Science
The general requirements for an engineer’s degree are given under Graduate Education in Part 1. These degrees are open to those able students in the doctoral or predoctoral program who seek more extensive training and research experiences than are possible within the master’s program. Admission to the engineer’s program depends upon a superior academic record and outstanding progress on a thesis. The course of studies consists of at least 162 units, 90 of which must be graduate H-level, and the thesis requirements for a master’s degree.

Doctor of Philosophy or Doctor of Science
The general requirements for the degree of Doctor of Philosophy or Doctor of Science are given under Graduate Education in Part 1. Doctoral candidates are expected to participate fully in the educational program of the department and to perform thesis work that is a significant contribution to knowledge. As preparation, MIT students in the Master of Engineering in Electrical Engineering and Computer Science program will be expected to complete that program. Students who have received a bachelor’s degree outside the department, but who have not completed a master’s degree program, will normally be expected to complete the requirements for the Master of Science degree described earlier, including a thesis. Students who have completed a master’s degree elsewhere without a significant research component will be required to register for and carry out a research accomplishment equivalent to a master’s thesis before being allowed to proceed in the doctoral program.

Details of how students in the department fulfill the requirements for the doctoral program are spelled out in an internal memorandum. The department does not have a foreign language requirement, but does require an approved minor program.

Graduate students enrolled in the department may participate in the interdisciplinary centers described in Part 3, such as the Center for Biomedical Engineering and the Operations Research Center.

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 to MIT), by a fellowship or traineeship awarded by MIT, or by a graduate assistantship. Assistantships require participation in research or teaching in the department or in one of the associated laboratories. Full-time assistants may register for no more than two scheduled classroom or laboratory subjects during the term, but may receive additional academic credit for their participation in the teaching or research program.

Inquiries
Additional information concerning graduate academic and research programs, admissions, financial aid, and assistantships may be obtained from the Electrical Engineering and Computer Science Graduate Office, Room 38-444, 617-253-4605, or http://www-eecs.mit.edu/.

Other Degree Programs
Joint Program with the Woods Hole Oceanographic Institution/ Course 6-W
The Joint Program with the Woods Hole Oceanographic Institution is intended for students whose primary career objective is oceanographic engineering. Students divide their academic and research efforts between the campuses of MIT and WHOI. The program is described in more detail under Interdisciplinary Graduate Programs in Part 3.

Computation for Design and Optimization
The Computation for Design and Optimization (CDO) program offers a master’s degree to students interested in the analysis and application of computational approaches to designing and operating engineered systems. The curriculum is designed with a common core serving all engineering disciplines and an elective component focusing on specific applications. Current MIT graduate students may pursue a CDO master’s degree in conjunction with a department-based master’s or PhD program. For more information, see the full program description under Interdisciplinary Graduate Programs in Part 3, or visit http://computationalengineering.mit.edu/education/.

Master of Science in Engineering and Management
The System Design and Management (SDM) program is a partnership among industry, government, and the university for educating
technically grounded leaders of 21st-century enterprises. Jointly sponsored by the School of Engineering and the Sloan School of Management, it is MIT’s first degree program to be offered with a distance learning option in addition to a full-time in-residence option. For more information, see the program description under Engineering Systems Division or visit http://sdm.mit.edu/.

Leaders for Global Operations Program
The 24-month Leaders for Global Operations (LGO) program combines graduate education in engineering and management for those with two or more years of full-time work experience who aspire to leadership positions in manufacturing or operations companies. A required six-month internship comprising a research project at one of LGO’s partner companies leads to a dual-degree thesis, culminating in two master’s degrees—an MBA (or SM in management) and an SM from Aeronautics and Astronautics. The program is offered jointly through the MIT Sloan School of Management and the School of Engineering. For more information, visit http://lgo.mit.edu/ or see the program description under Engineering Systems Division.

Master of Science in Technology and Policy
The Master of Science in Technology and Policy is an engineering research degree with a strong focus on the role of technology in policy analysis and formulation. The Technology and Policy Program (TPP) curriculum provides a solid grounding in technology and policy by combining advanced subjects in the student’s chosen technical field with courses in economics, politics, and law. Many students combine TPP’s curriculum with complementary subjects to obtain dual degrees in TPP and either a specialized branch of engineering or an applied social science such as political science or urban studies and planning. For additional information, see the program description under Engineering Systems Division or visit http://web.mit.edu/tpp/.

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The Engineering Systems Division (ESD) tackles complex, large-scale problems utilizing faculty from most academic departments in the School of Engineering, as well as faculty from all five MIT schools. The mission of ESD is to solve previously intractable engineering systems problems by integrating approaches based on engineering, management, and social sciences, using new framing and modeling methodologies. MIT established the division in 1998 with the charter to develop academic and research programs that educate future leaders in our technological age, serve as a model to broaden engineering education, and expand the scope and practice of engineering. To accomplish these goals, ESD actively develops innovative relationships with industry and government through collaborative global research projects and long-distance educational programs. ESD focuses primarily on the following domains: extended enterprises, critical infrastructures, energy and sustainability, and health care delivery.

Designing engineering systems is increasingly difficult as the systems increase in size, scope, and complexity. The rate of change is increasing, often due to forces of globalization, new technological capabilities, rising consumer expectations, and increasing social awareness. Purely technical approaches to analysis and design of these systems often lead to failure, as a more comprehensive approach is required. Consequently, knowledgeable development of engineering systems calls for new frameworks of analysis and design that are broader than those of the traditional single-discipline paradigms of individual engineering departments. The effective design of engineering systems requires an integrative approach in which engineering systems professionals view the technological system as part of a larger whole. While the ESD approach is broad, it must also retain the depth associated with the traditional single-discipline approach. ESD is founded on the recognition that new approaches, frameworks, and theories—both broad and deep—must be developed to analyze and design complex systems.

The Engineering Systems Division encompasses five master’s programs: Technology and Policy (TPP), Supply Chain Management (SCM), the Leaders for Global Operations (LGO), System Design and Management (SDM), and a Master of Science in Engineering Systems. The core educational and research activity of ESD is the doctoral program in engineering systems, which prepares students for careers in academia, industry, and government.

ESD initiates research focused on important national and international issues that have science and technology components. These build upon the existing research programs in the Center for Transportation and Logistics; the Center for Engineering Systems Fundamentals; the Sociotechnical Systems Research Center; and the MIT Portugal Program.

ESD’s educational and research programs are deeply involved with industry, government, and engineering practice in general. Units within ESD have many, often novel, relationships with industry. Examples include: consortia formed around the International Motor Vehicle and the Lean Advancement programs in the Center for Engineering Systems Fundamentals; the Center for Transportation and Logistics’ Supply Chain Exchange, the Integrated Supply Chain Management Program, and the AgeLab; and corporate partnerships of the Leaders for Global Operations and the System Design and Management programs.

Application forms for all programs can be accessed from [http://web.mit.edu/admissions/graduate/](http://web.mit.edu/admissions/graduate/). Applicants whose first language is not English must offer evidence of written and oral proficiency in English by registering for the International English Language Testing System (IELTS) exam, academic format, and achieving a score of 7.5 or better. Information about the Graduate Record Examinations (GRE) and Graduate Management Admissions Test (GMAT) is available at [gre-info@ets.org](http://www.ielts.org/) and [gmat@ets.org](http://www.ielts.org/). Applicants should refer to the details of each program concerning specific requirements for admission. Links to all of the programs can be found at [http://esd.mit.edu/](http://esd.mit.edu/).

For details, please refer to ESD’s Academic Office (esdgrad@mit.edu) and to the MIT Sloan School of Management for programs offering joint degrees.

**MASTER’S PROGRAMS**

**Master of Science in Technology and Policy**

The Technology and Policy Program (TPP) educates students seeking leadership roles in the constructive development and use of technology—an area that is not well served by the traditional education of technical or social science specialists. TPP focuses on meeting the need for engineering leaders who are capable of dealing effectively with core technical issues in their full economic, political, and administrative contexts.

TPP educates “leaders who are engineers and scientists”—persons who have strong technical foundations as well as the skills and ability to deal with important strategic issues concerning the intelligent and effective development of technology.

The Master of Science in Technology and Policy is an engineering research degree with a focus on the increasingly central role of technology in the framing, formulation, and resolution of policy problems. Many students combine TPP’s curriculum with complementary subjects to obtain dual degrees in TPP and either a specialized branch of engineering or an applied social science such as political science or urban studies and planning.

TPP’s coursework provides a solid grounding in technology and policy by combining advanced subjects in the student’s chosen technical field with courses in economics, politics, and law. All students must complete a satisfactory research thesis that has a substantial technology and policy component. In order to prepare students for effective professional practice, TPP stresses leadership and communication. It also encourages students to participate in TPP’s summer internship program, which places students in government and industry in the US and around the world.

The TPP curriculum consists of three blocks of subjects and a research thesis. The first block is a required integrative subject in technology and policy and a set of program seminars focusing on leadership and presentation skills. The second block focuses on training in formal frameworks for policy development and consists of restricted electives in microeconomics, polit-
cal economy, and legal processes. The third block comprises a minimum of three coherent electives that fulfill professional and research objectives.

Completion of the academic and research requirements of the TPP SM typically takes three or four terms.

The subjects required for the TPP degree include ESD.10 Introduction to Technology and Policy and the following subjects or their equivalents: 15.011 Economic Analysis for Business Decisions, ESD.103 Science, Technology, and Public Policy, and ESD.152 Law, Technology, and Public Policy. Students are strongly encouraged to take ESD.71 Engineering Systems Analysis for Design, particularly those considering doctoral studies in ESD.

The TPP curriculum normally begins in September; applications are due by December 15. All applicants should have a strong basis in engineering or science, and must take the GRE. Strong candidates for the program typically score in the top 10 percent of all three GRE areas: verbal, quantitative, and analytic writing. Participants in TPP should generally have two years of work experience and be able to demonstrate evidence of leadership and initiative in their professional or other activities.

Contact the TPP program office in Room E40-369, 617-253-7693, tpp@mit.edu, or visit http://web.mit.edu/tpp/ for additional information.

Supply Chain Management Program
The Supply Chain Management Program is designed to supply the global logistics industry with a new type of supply chain professional, who is highly trained in both analytical problem solving and change management leadership. The one-of-a-kind professional degree program offered through ESD’s Center for Transportation & Logistics prepares graduates for logistics and supply chain management careers in manufacturing, distribution, retail, transportation, logistics, consulting, and software development organizations.

The MIT Supply Chain Management Program leads to a Master of Engineering in Logistics (MLOG), which is completed in nine months (September through May) on the MIT campus in Cambridge, MA. During that time, students take specialized classes taught by leading logistics and supply chain professionals in areas such as logistics systems, supply chain design, inventory planning, and transportation management. In addition, students are given the opportunity to work closely with corporate members of the Center for Transportation & Logistics on research projects and travel to our global logistics center in Spain—for a supply chain education that spans the globe.

The MIT Supply Chain Management Program requires 90 MIT credit units: eight required subjects and the completion of a thesis project. Students also take at least nine credit units of electives. Students who have already taken one of the required subjects at a graduate level elsewhere can petition to replace that subject with another elective.


The program is primarily for students with industry experience, but is open to anyone who can meet the entrance requirements. Applicants should have a background in college level calculus, economics, probability and statistics. All applicants for the MLOG degree must take the GRE General Test or GMAT. Applicants whose first language is not English must take the IELTS exam and achieve a score equal to or higher than 7.5.

The MIT Supply Chain Management Program curriculum begins in September. There are two admission rounds. The round 1 deadline is January 10, 2011; the round 2 deadline is April 4, 2011. Applications and requests for additional information should be directed to the MIT Supply Chain Management Program Admissions Office, Room E40-359, 617-324-6564, scm@mit.edu, or visit http://scm.mit.edu/.

System Design and Management Program
MIT’s System Design and Management (SDM) program, offered jointly by the School of Engineering and the MIT Sloan School of Management, is a master’s degree program for technical professionals who seek to build upon their backgrounds and experience in order to advance to positions of leadership in their profession.

The SDM program offers the degree of Master of Science in Engineering and Management. Students take subjects drawn from three areas: systems (systems engineering, architecture, and optimization), management, and a technical area of the student’s choosing.

SDM provides both on-campus instruction for resident degree students and distance learning instruction for technical professionals who are continuing in their positions at remote locations while enrolled in the program. The 13-month full-time program that begins in January requires 11 courses, 3 electives, a thesis seminar, and a thesis. The distance learning program requires 24 months to complete, with an initial January on campus followed by five semesters of distance education classes; students spend one semester in residence at MIT, and the total course requirements, including thesis, are the same as for the full-time, 13-month program.

The required courses span a combination of engineering and management topics, with leadership and teamwork modules interwoven in the curriculum. Core subjects include ESD.34J System Architecture, ESD.33J Systems Engineering, and ESD.36J System and Project Management. The remainder of the required subjects are one quantitative methods course (typically ESD.721 Engineering Risk-Benefit Analysis), ESD.762 Systems Optimization, one product development course (typically ESD.40 Product Design and Development), 15.381 The Human Side of Technology, ESD.763 Operations and Supply Chain Management or another operations course, 15.969 User-centered Innovation in the Internet Age, 15.905 Technology Strategy for SDM, and 15.514 Financial and Managerial Accounting.

All required subjects are taught on campus and via distance education. Elective selection is driven by the student’s career objectives in consultation with the SDM program executive director. Students take one engineering and one management elective, and one design or product development elective, in addition to selected courses to fill the leadership requirement.

The ideal applicant for the SDM program will have a master’s degree in engineering or the
equivalent and three or more years as a product development professional, including experience as a team leader. Students with a bachelor’s degree and five years of professional experience, including leadership experience, are encouraged to apply.

The SDM program begins in January. Potential student fellows may apply via the web at http://sdm.mit.edu/apply.html. For additional information contact the SDM Program Office in Room E40-315, 617-253-1055, sdm@mit.edu, or visit http://sdm.mit.edu/.

Leaders for Global Operations
An active partnership among the School of Engineering, the Sloan School of Management, and partner companies, the MIT Leaders for Global Operations (LGO) program develops world-class leaders for manufacturing and operations. LGO focuses on theory and global practice from concept development through product delivery, including challenges faced on factory floors and in global supply chains. Corporate partners provide generous fellowships for all students.

The LGO program leads to two MIT master’s degrees: an SM from ESD (or another participating engineering department) and an MBA or SM from the MIT Sloan School of Management. All applicants must take the GRE. Alternatively, anyone applying through Sloan may choose to take the GMAT.

For additional information, visit http://lgo.mit.edu/, contact the LGO program office at lgo@mit.edu or 617-253-1055, or see any of the participating engineering departments and the MIT Sloan School of Management.

Master of Science in Engineering Systems
The SM in Engineering Systems is an engineering degree available to students with an undergraduate degree in engineering or science. The degree focuses on the design and implementation of socio-technical systems. The ESD SM can be a terminal degree that prepares the student for productive practice, or it can be obtained during the ESD PhD program. The ESD SM allows ESD faculty and students to work together on issues of mutual interest different from those covered by the other masters’ programs that are part of ESD (i.e., the Technology and Policy, Supply Chain Management, and System Design and Management programs described elsewhere in this chapter). It can also serve as the engineering SM for students in the Leaders for Global Operations program.

For details on admission to the ESD SM, see the Frequently Asked Questions about Admissions at http://esd.mit.edu/academics/smis_admissions.html. Admissions decisions are made once a year. Applications are due December 15.

Doctoral Program
ESD’s doctoral students are leaders in the evolution of engineering systems approaches—committed to thinking imaginatively about ways to broaden engineering’s scope to solve complex problems. In the course of their studies, students acquire broad knowledge of the field of engineering systems and deep knowledge of a domain and of a methodology. By the time a student defends his or her thesis, he or she has conducted original scholarship on complex technical systems, advancing either theory, policy, or practice.

As with the Engineering Systems Division as a whole, the research done by students in the doctoral program can be categorized into several broad areas. Students do work in the domains of energy and sustainability, extended enterprises, health care delivery, and critical infrastructures. Students use approaches that examine the interface of humans and technology or that measure, model, and mitigate the effects of uncertainty. Students work to improve the design and implementation of large, complex systems. Students deploy network models to understand complexly related social, technical, and managerial entities.

To accommodate the diversity of domains and approaches, ESD doctoral programs are highly individualized. PhD students and their committees construct programs that “go deep” in the domains and methodologies a student’s research requires. Breadth of knowledge about the field of engineering systems is also essential. Alongside domain and methodology requirements, all students must take ESD.83 Doctoral Seminar in Engineering Systems, ESD.86 Models, Data and Inference for Socio-Technical Systems, ESD.87 Social Science Concepts and Methods, and an applied engineering systems subject. For details on the program, see http://esd.mit.edu/academics/phd.html.

Admission to the ESD PhD program is based upon outstanding academic performance in engineering or applied science, GRE scores, demonstrated fluency in English, deep interest in engineering systems as a field of study, and letters of recommendation. Admissions decisions are made once a year. All applications for the cohort forming in September are due
December 15. For additional information, please visit the Frequently Asked Questions about Admissions at http://esd.mit.edu/academics/phd_admissions.html.

**Human-Systems Engineering Track**
The human-systems engineering (HSE) track within ESD focuses on the characteristics of people—including organizational, social, and cognitive—throughout the system conception, development, validation, and operation processes.

Areas of focus in the HSE track include human interaction with transportation systems (rail, aviation, automobile), human interaction with robotic/autonomous systems, process control, and heterogeneous systems which contain elements of more than one system (such as network-centric operations). Example domains include air traffic control, military command and control of manned and/or unmanned systems, first responder systems, and driving interactions.

The HSE track fits within the already established SM and PhD programs for ESD and TPP. It is a two-year program at the SM level, and three or more years beyond the SM for the PhD program. The core classes remain the same as already established for ESD students with the following changes:

- Either ESD.756] Statistical Methods in Experimental Design or ESD.86 Models, Data and Inference for Socio-Technical Systems
- ESD.774] Human Supervisory Control of Automated Systems

For more information visit http://esd.mit.edu/hse/ or contact Missy Cummings at missyc@mit.edu.

**Research Centers**

**Center for Engineering Systems Fundamentals**
ESD’s center for Engineering Systems Fundamentals (CESF) was founded in September 2005 to conduct research on the fundamentals and cross-cutting issues in engineering systems.

CESF is engaged in several areas, among them developing seminars and other mechanisms to discuss engineering systems fundamentals; collaborating with faculty to bring in resources for CESF and shape its relationships with ESD’s other research centers, including the Sociotechnical Systems Research Center and the Center for Transportation and Logistics; and sponsoring an engineering systems book series and a biannual international symposium on engineering systems fundamentals. CESF seeks to establish cross-cutting research projects on problems of national significance that require integration of the methods of engineering, management, and the social sciences. Through the interdisciplinary framing, formation, and solution of socio-technical systems problems, this process should lead to the creation of engineering systems fundamentals. Current major projects include analysis of low-probability high-consequence events such as pandemic influenza and food supply contamination; K–12 and K–16 education systems innovations for students pursuing science, technology, engineering, or mathematics careers; and demand-side home energy management.

**Center for Transportation & Logistics**
For more than 35 years, the MIT Center for Transportation & Logistics (MIT CTL) has been a world leader in supply chain management and transportation education and research. MIT CTL engages in three principal activities: research, outreach, and education.

**Research**
The center’s world-renowned research programs directly involve over 75 faculty and research staff from a wide range of academic disciplines, as well as researchers in various affiliate organizations around the world. MIT CTL has three main research programs: Supply Chain Management and Logistics, Transportation, and the impact of aging on mobility, health, and wellness.

In the field of supply chain management and logistics, MIT CTL has made major knowledge contributions and helped numerous companies gain competitive advantage from its cutting-edge research. Research projects include:

- Carbon Efficient Supply Chains
- Demand Management
- FreightLab
- Healthcare Supply Chain
- Scenario Planning
- Strategy Alignment

**Outreach**
The gateway to the center’s research is MIT CTL’s Corporate Outreach Program. Through this multifaceted program, industry and MIT CTL collaborate to turn innovative research into market-winning commercial applications. The center currently has more than 45 corporate partners worldwide who participate in its events, interact with its researchers, and contribute to and help steer its research projects.

**Education**
In education, MIT is consistently ranked first among business programs in logistics and supply chain management. MIT CTL graduate degrees and executive-level programs are unsurpassed for quality and market relevance.

The MIT Supply Chain Management (SCM) program attracts business professionals from across the globe to participate in its intensive logistics and supply chain management program. The SCM program is described under Master’s Programs earlier in this chapter.

An ESD doctoral program can be focused on logistics and supply chain management as well.
Through MIT CTL, MIT is the lead university in Federal Region I of the University Transportation Centers program administered by the US Department of Transportation. Through this program, full and partial fellowships are awarded to graduate students in transportation. Research and teaching assistantships also are available through this and other programs. Undergraduates also may participate in sponsored research through the Undergraduate Research Opportunities Program.

Students interested in studying supply chain management and logistics, or in learning more about the center and its educational programs, should write to Dr. Bruce Arntzen, MIT Center for Transportation and Logistics, Room E40-355, barntzen@mit.edu, or visit http://scm.mit.edu/.

Students interested in the Master of Science in Transportation program administered through the Department of Civil and Environmental Engineering should contact the director of the Transportation Graduate Program. Several departments offer both master's and doctoral degrees that allow a focus on transportation, including Aeronautics and Astronautics, Civil and Environmental Engineering, the Engineering Systems Division, and Urban Studies and Planning.

**Sociotechnical Systems Research Center**

MIT's Sociotechnical Systems Research Center (SSRC) is an interdisciplinary research and educational center addressing global technology, health, and policy issues through partnerships with industry, government, and academia. Center programs include the Center for Biomedical Innovation, the Center for Engineering Systems Fundamentals, the Ford-MIT Alliance, the Geospatial Data Center, the Lean Advancement Initiative, and the Systems Engineering Advancement Initiative.

For further information on SSRC and its programs, see Interdisciplinary Research and Study in Part 3.

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**Sociotechnical Systems Research Center**

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Center programs include the Center for Biomedical Innovation, the Center for Engineering Systems Fundamentals, the Ford-MIT Alliance, the Geospatial Data Center, the Lean Advancement Initiative, the Materials Systems Laboratory, MIT Information Quality, and the Systems Engineering Advancement Initiative.

For further information on SSRC and its programs, see Interdisciplinary Research and Study in Part 3.
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Codirector, Singapore–MIT International Design Center

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Frances and David Dibner Professor of the History of Engineering and Manufacturing Professor of Engineering Systems
Director, Science, Technology, and Society Program

Fred Moavenzadeh, PhD
James Mason Crafts Professor Professor of Civil and Environmental Engineering and Engineering Systems
Director, Technology and Development Program (On leave)

Ernest Moniz, PhD
Cecil and Ida Green Professor of Physics and Engineering Systems
Director, Laboratory for Energy and the Environment
Director, MIT Energy Initiative

Joel Moses, PhD
Professor of Computer Science and Engineering Systems
Institute Professor

Dava J. Newman, PhD
Professor of Aeronautics and Astronautics and Engineering Systems
Director, Technology and Policy Program
Director, MIT Portugal Program

Deborah Nightingale, PhD
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Codirector, Lean Advancement Initiative Director, Sociotechnical Systems Research Center

Alex Pentland, PhD
Toshiba Professor of Media Arts and Sciences and Engineering Systems
Director, Media Lab Entrepreneurship Program
Director, Human Dynamics Laboratory

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César Hidalgo, PhD
Assistant Professor of Media Arts and Sciences and Engineering Systems
Noelle Eckley Selin, PhD
Assistant Professor of Engineering Systems and Atmospheric Chemistry
Jessika Trancik, PhD
Assistant Professor of Engineering Systems
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Senior Lecturers
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Senior Lecturer, Engineering Systems
Christopher Caplice, PhD
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Joseph Coughlin, PhD
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Jarrod Goentzel, PhD
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Professor of Engineering Systems, Emeritus
David Hunter Marks, PhD
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Sanjoy Mitter, PhD
Professor of Electrical Engineering and Engineering Systems, Emeritus
Daniel Roos, PhD
Japan Steel Industry Professor of Civil and Environmental Engineering and Engineering Systems, Emeritus
Materials science and engineering is a field broadly based in chemistry, physics, and the engineering sciences. The field is concerned with the design, manufacture, and use of all classes of materials (including metals, ceramics, semiconductors, polymers, and biomaterials), and with energy, environmental, health, economic, and manufacturing issues relating to materials. Materials science and engineering is a field critical to our future economic and environmental well-being.

Materials science emphasizes the study of the structure of materials and of processing—structure-property relations in materials. Almost all 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, and 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 fundamental relationships between structure and properties and how the structure can be changed and controlled by the various chemical, thermal, mechanical, or other treatments to which a material is subjected during manufacture and in use. The fundamental understanding of materials developed through materials science has replaced empiricism as the basis for discovery of new materials. Whole classes of new materials such as semiconductors, superconductors, and high-temperature alloys have their roots in modern materials science.

Recent achievements in materials have depended as much on advances in materials engineering as they have on materials science. When developing engineering processes for preparation and production of materials, and when designing materials for specific applications, the materials engineer must understand fundamental concepts such as thermodynamics, and heat and mass transfer and chemical kinetics, and must also have a proper concern for economic, social, and environmental factors. Today's materials scientists and engineers are well equipped to address some of the key challenges facing humanity, including energy generation and storage and the environmental impact of human activities, and to improve human health and well-being.

Materials engineering and materials science are interwoven in the department. There are some subjects that all students of materials should know: thermodynamics, kinetics, materials structure, electronic and mechanical properties of materials, bio- and polymeric materials, and materials processing. Core subjects in these areas are offered at the undergraduate and graduate levels. In addition, elective subjects covering a wide range of topics are offered. Lectures are complemented by a variety of laboratory experiences. By selecting appropriate subjects, the student can follow many different paths with emphasis on engineering, science, or a mixture of the two. In addition, students may pursue a path in archaeology and archaeological science by selecting subjects that focus on archaeological materials research within the Department of Materials Science and Engineering and the Center for Materials Research in Archaeology and Ethnology. This curriculum is unique within departments of anthropology, archaeology, and engineering.

Materials engineers and materials scientists, whether generalists or specialists in a particular class of material, are in continually high demand by industry and government for jobs in research, development, production, and management. They find challenging opportunities in diverse important positions in companies working on energy and the environment, in the electronics industry, in the aerospace industry, in consumer industries, and in biomaterials and medical industries. A large number of DMSE alumni are faculty of leading universities.

The department has modern undergraduate materials teaching laboratories containing a wide variety of materials processing and characterization equipment. The Undergraduate Teaching Laboratory on the Infinite Corridor includes facilities for biomaterials research, chemical synthesis, and physical and electronic properties measurement. The new Laboratory for Advanced Materials, located across the hall, was completed in 2010. It contains new characterization equipment for scanning acoustical microscopy, near-field and scanning laser confocal microscopes, and low-temperature multiprobe. Other departmental facilities include those for preparation and characterization of thin films, ceramics and glasses, metallic and nonmetallic crystals, biomaterials, and polymers. Equipment is available for the study of mechanical properties in the Nanomechanics Laboratory, and for metal casting and joining in the Foundry. Materials are characterized by optical, electron (TEM, SEM), and scanning probe (AFM, STM) microscopy, and there is equipment for a wide range of electrical optical, magnetic, and mechanical property measurements.

UNDERGRADUATE STUDY

The Department of Materials Science and Engineering offers three undergraduate degree programs:

- Course 3, leading to the Bachelor of Science in Materials Science and Engineering, is taken by the majority of undergraduates in the department, and is accredited by the Accreditation Board for Engineering and Technology (ABET).
- Course 3-A, leading to the Bachelor of Science without specification, provides greater flexibility to the student in designing his or her professional program, and is often taken by pre-med, pre-law, or pre-MBA students.
- Course 3-C provides a Bachelor of Science in Archaeology and Materials.

The department also offers research and educational specialization in a large number of industrially and scientifically important areas leading to master's and doctoral degrees.

Bachelor of Science in Materials Science and Engineering/Course 3

The undergraduate program serves the needs of students who intend to pursue employment in materials-related industries immediately upon graduation, as well as those who will do graduate work in the engineering or science of materials. The program is designed to be started at the beginning of the sophomore year, although it can be started in the spring term of the sophomore year or in the junior year with some loss of scheduling flexibility.

The first four academic terms of the program contain required core subjects that address the fundamental relations between processing, microstructure, properties, and applications.
of modern materials. The core subjects are followed by a sequence of restricted electives that provide more specialized coverage of the major classes of modern materials: biomaterials, ceramics, electronic materials, metals, and polymers, as well as cross-cutting topics relevant to all types of materials. Course 3 students write either a senior thesis or an internship report based on a summer industrial internship. This provides an opportunity for original research work beyond that which occurs elsewhere in the program.

The required subjects can be completed in the sophomore and junior years within a schedule that allows students to take a HASS subject each term, and a range of elective junior and senior subjects. Departmental advisors work with students to assist in selecting elective subjects suitable to the student’s needs and interests. While the program should satisfy the academic needs of most students, petitions for variations or substitutions may be approved by the departmental Undergraduate Committee; students should contact their advisor for guidance in such cases.

Participation in laboratory work by undergraduates is an integral part of the curriculum. The departmental core subjects include extensive laboratory exercises, which investigate materials properties, structure, and processing, and are complementary to the lecture subjects. The junior-year core includes a capstone laboratory subject, 3.042, that emphasizes design, materials processing, teamwork, communication skills, and project management. Undergraduate students also have access to extensive facilities for research in materials as part of UROP and thesis projects. Engineering design figures prominently in a substantial portion of the laboratory exercises. Students develop oral and written communication skills by reporting data and analysis in a variety of ways.

Students may substitute industrial internship reports (12 units of 3.930/3.931 Industrial Practice) for the senior thesis (3.0Th). Students should select this option during their sophomore year, and take 3.930 in the summer after the sophomore year and 3.931 in the summer following the junior year. This option provides a student with industrial experience concurrently with academic work through cooperative work assignments matched to the student’s capabilities and arranged by the department. Together with a company representative, a faculty advisor is assigned to each student to assist as co-supervisor during his or her work assignments. Students earn a salary during their work periods and also receive academic credit.

**Bachelor of Science/Course 3-A**

Some students may be attracted to the many opportunities available in the materials discipline, but also have special interests that are not satisfied by the Course 3 program. For instance, some students may wish to take more biology and chemistry subjects in preparation for medical school, or more management subjects prior to entering an MBA or law program. In these cases, the 3-A program may be of value as a more flexible curriculum in which a larger number of elective choices is available.

The curriculum requirements for Course 3-A are similar to, but more flexible than, those for Course 3. Five subjects chosen from the core (3.012; 3.016, 16.03, or 18.034; 3.021, 3.016, 1.00, or 6.01; 3.022; 3.024; 3.032; 3.034; 3.042; and 3.044) and one laboratory subject (3.014) are required, along with any three additional subjects (36 units) selected from the list of Restricted Electives shown under Course 3. In addition to these nine subjects, the student should develop a program of six planned elective subjects appropriate to the student’s stated goals. CI-M designated subjects for Course 3-A include 3.014, 2.099, 2.671, 3.042, 3.155I, 5.36, 5.38, 6.021J/2.791J/20.370J, 7.02, 10.26, 10.28, 10.29, and 10.467.

As an example of a 3-A program, a student planning a career in medicine might select the following subjects in addition to the above requirements in order to satisfy the premedical requirements recommended by the MIT Global Education and Career Development Center: 7.02, 5.12, 5.13, 5.310, 7.05.

Students considering the 3-A program should contact the departmental advisor (Professor David Roylance, roylance@mit.edu), who will counsel the student more fully on the academic considerations involved. Under his guidance, the student will prepare a complete plan of study which must be approved by the departmental Undergraduate Committee. This approval must be obtained no later than the beginning of the student’s junior year. Students are then expected to adhere to this plan unless circumstances require a change, in which case a petition for a modified program must be submitted to the Undergraduate Committee. The department does not seek ABET accreditation for the 3-A program.

**Bachelor of Science in Archaeology and Materials as Recommended by the Department of Materials Science and Engineering/Course 3-C**

Students who have a specific interest in archaeology and archaeological science may choose Course 3-C. The 3-C program is designed to afford students broad exposure to fields that contribute fundamental theoretical and methodological approaches to the study of ancient and historic societies. The primary fields include anthropological archaeology, geology, and materials science and engineering. The program enriches knowledge of past and present-day nonindustrial societies by making the natural and engineering sciences part of the archaeological tool kit.

The program’s special focus is on understanding prehistoric culture through study of the structure and properties of materials associated with human activities. Investigating peoples’ interactions with materials, the objects that such interactions produced, and the related environmental settings, leads to a fuller analysis of the physical, social, cultural, and ideological world in which people function. These are the goals of anthropological archaeology, goals that are reached, in part, through science and engineering perspectives.

Participation in laboratory work by undergraduates is an integral part of the curriculum. The program requires that all students take a materials laboratory subject. Many of the archaeology subjects are designed with a laboratory component; such subjects meet in the Undergraduate Archaeology and Materials Laboratory. Undergraduate students also have access to the extensive CMRAE facilities for research in archaeological materials as part of UROP and thesis projects. Such projects may include archaeological fieldwork during IAP or the summer months.

The **HASS Concentration in Archaeology and Archaeological Science** provides concentrations with a basic knowledge of the field of archaeol-
ogy, the systematic study of the human past. Students pursuing the SB in 3-C may not also concentrate in this area. The archaeology and archaeological science concentration consists of four subjects: 3.986, 3.985J, and two other HASS electives from among those currently offered in this subject area: 3.094, 3.982, 3.983J, 3.987, 3.988, 3.993. The department does not seek ABET accreditation for the 3-C program. Students may contact Dr. Harry Merrick for more information.

Minors

The Minor in Materials Science and Engineering consists of six undergraduate subjects totalling at least 72 units from the list of Required Subjects and Restricted Electives in the departmental program, with at least one of these taken from the list of Restricted Electives. With the approval of the minor advisor, it may be possible to substitute one subject taken outside the department for one of the Course 3 subjects in the minor program, provided that the coverage of the substituted subject is similar to one of those in the departmental program.

The department’s minor advisor, Professor David Roylance, will ensure that individual minor programs form a coherent group of subjects. Other suitable programs may be composed through consultation between students, the minor advisor, and the Undergraduate Committee.

The Minor in Archaeology and Materials (3-C) consists of six undergraduate subjects totalling 72 units. The five required subjects are 3.012 Fundamentals of Materials Science and Engineering, 3.014 Materials Laboratory, 3.022 Microstructural Evolution in Materials, 3.986 The Human Past: Introduction to Archaeology (HASS-S), and 3.985 Archaeological Science (HASS-S). The sixth subject is an elective from the Archaeology and Archaeological Science subject listings. With the approval of the minor advisor, it may be possible to substitute one subject

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### Bachelor of Science in Materials Science and Engineering/Course 3

<table>
<thead>
<tr>
<th>General Institute Requirements (GIRs)</th>
<th>Subjects</th>
<th>Units</th>
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<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
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<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>8</td>
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<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement [can be satisfied by 3.012 and 3.021]</td>
<td>2</td>
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<tr>
<td>in the Departmental Program</td>
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<tr>
<td>Laboratory Requirement [can be satisfied by 3.014 in the Departmental Program]</td>
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<tr>
<td>Total GIR Subjects Required for SB Degree</td>
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<tr>
<td>Communication Requirement</td>
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<tr>
<td>The program includes a Communication Requirement of 4 subjects: 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and 2 subjects designated as Communication Intensive in the Major (CI-M).</td>
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<tr>
<td>PLUS Departmental Program</td>
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<tr>
<td>Subject names below are followed by credit units, and by prerequisites if any (corequisites in italics).</td>
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<tr>
<td>Required Subjects</td>
<td>128–138</td>
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<tr>
<td>3.012 Fundamentals of Materials Science and Engineering, 15, REST; 18.03*</td>
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<tr>
<td>3.014 Materials Laboratory, 12, LAB, CI-M</td>
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<td>One of the following three subjects:</td>
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<tr>
<td>3.016 Mathematical Methods for Materials Scientists and Engineers, 12; Calculus II (GIR)*</td>
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<tr>
<td>18.03 Differential Equations, 12, REST; Calculus II (GIR)</td>
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<tr>
<td>18.034 Differential Equations, 12, REST; Calculus II (GIR)</td>
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<tr>
<td>One of the following four subjects:</td>
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<tr>
<td>3.021 Introduction to Modeling and Simulation, 12, REST; 18.03*</td>
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<tr>
<td>1.00 Introduction to Computers and Engineering Problem Solving, 12, REST; Calculus I (GIR)</td>
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<tr>
<td>0.01 Introduction to EECS I, 12, 1/2 LAB; Physics II (GIR)</td>
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<tr>
<td>3.016 Mathematical Methods for Materials Scientists and Engineers, 12; Calculus II (GIR)*</td>
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<tr>
<td>3.022 Microstructural Evolution in Materials, 12; 3.012</td>
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<td>3.024 Electronic, Optical, and Magnetic Properties of Materials, 12; 3.012</td>
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<td>3.032 Mechanical Behavior of Materials, 12; Physics I (GIR), 3.016*</td>
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<td>3.034 Organic and Biomaterials Chemistry, 12; 3.012</td>
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<td>3.042 Materials Processing, 12; 3.012, 3.022</td>
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<td>3.044 Materials Processing, 12; 3.012, 3.022</td>
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<tr>
<td>3.046 Materials Processing, 12; 3.012, 3.022</td>
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<td>3.048 Advanced Materials Processing, 12; 3.022, 3.044</td>
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<td>3.051 Materials for Biomedical Applications, 12; Chemistry (GIR)*</td>
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<tr>
<td>3.052 Nanomechanics of Materials and Biomaterials, 12; 3.024*</td>
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<tr>
<td>3.053 Molecular, Cellular, and Tissue Biomechanics, 12; 18.03*, Biology (GIR), 2.370*</td>
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<td>3.055 Biomaterials Science and Engineering, 12; 3.024*</td>
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<td>3.057 Polymer Physics, 12; 3.012</td>
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<td>3.064 Polymer Engineering, 12; 3.032, 3.044</td>
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<td>3.07 Polymer Physics, 12; 3.012</td>
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<tr>
<td>3.072 Symmetry, Structure, and Tensor Properties of Materials, 12; 3.016*</td>
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<tr>
<td>3.073 Diffraction and Structure, 12; 18.03, 3.024</td>
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<td>3.074 Imaging of Materials, 12; 3.024*</td>
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<tr>
<td>3.080 Economic and Environmental Materials Selection, 12; 3.012*</td>
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<tr>
<td>3.14 Physical Metallurgy, 12; 3.012, 3.022, 3.032</td>
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<td>3.15 Electrical, Optical, and Magnetic Materials and Devices, 12; 3.024</td>
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<td>3.153 Nanoscale Materials, 12; 3.024</td>
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<td>3.154 Materials Performance in Extreme Environments, 12; 3.032, 3.044</td>
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<tr>
<td>3.155 Micro/Nano Processing Technology, 12, CI-M; permission of instructor</td>
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<tr>
<td>3.155J Micro/Nano Processing Technology, 12, CI-M; permission of instructor</td>
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</tbody>
</table>

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In the doctoral core, the general written examination covers material enrolled in doctoral programs in the department. The department’s 3-C minor advisor, Professor Dorothy Hosler, will ensure that the minor program forms a coherent group of subjects.

A general description of the minor program at MIT may be found under Undergraduate Education in Part 1.

**Inquiries**
Additional information regarding undergraduate programs may be obtained from Professor Lionel Kimerling, Room 13-4118, 617-253-5383, lckim@mit.edu, or from the Academic Office, Room 6-107, 617-258-5816.

**GRADUATE STUDY**

The Department of Materials Science and Engineering offers the degrees of Master of Science, Doctor of Philosophy, and Doctor of Science in Materials Science and Engineering.

**Doctoral Degree**
The subjects 3.20 Materials at Equilibrium, 3.21 Kinetic Processes in Materials, 3.22 Mechanical Properties of Materials, and 3.23 Electrical, Optical, and Magnetic Properties of Materials are basic to all doctoral degree programs and constitute a required core for all graduate students enrolled in doctoral programs in the department. The general written examination covers material in the doctoral core.

In the thesis area examination (oral presentation and examination), students are expected to learn the fundamentals of their chosen field and to develop a deep understanding of one or more of its significant aspects. Students are required to take three further subjects from an approved restricted electives list. A full range of advanced-level subjects is offered in a variety of topics, and arrangements can be made for individually planned study of any relevant topic. The thesis area examinations for the doctoral degree are designed accordingly. In addition, students are required to take a two- or three-subject minor program.

A large and active research program on the structure and properties, preparation, and processing of materials, with emphasis on ceramics, electronic materials, metals, polymers, and biomaterials, is conducted in the department. Graduate research is considered the central part of the educational process, and emphasis is placed on the research thesis. Students choose research projects from the many opportunities that exist within the department, and work closely with an individual faculty member. The results of the thesis must be of sufficient significance to warrant publication in the scientific literature.

The department maintains a large number of well-equipped research laboratories, and there is significant interaction between them, including the sharing of experimental facilities and equipment. Most department members have access to the Center for Materials Science and Engineering, which provides and maintains excellent central facilities, or the Materials Processing Center. Both centers provide interdisciplinary research opportunities as described in Interdisciplinary Research and Study in Part 3.

**Interdisciplinary Doctoral Program in Archaeological Materials**
The Department of Materials Science and Engineering offers an interdisciplinary doctoral program for individuals who wish to consider the study of archaeology and materials science and pursue research in the field of archaeological materials. Admission to the program is through the department. The program requires four core subjects—half in materials science and engineering, half in archaeology—and six additional subjects. Many of the subject requirements may be met with coursework in the Architecture; Civil and Environmental Engineering; Earth, Atmospheric, and Planetary Sciences; Mechanical Engineering; and Urban Studies and Planning departments; or additionally in the Technology and Policy Program; the Program in Science, Technology, and Society; and the Anthropology Department at Harvard University. Field research opportunities are available, most notably in Mesoamerica and South America.

**Interdisciplinary Doctoral Program for Polymer Science and Technology**
See Interdisciplinary Graduate Programs in Part 3 for information on this program.

**Master of Science in Materials Science and Engineering**
The department offers a Master of Science degree in materials science and engineering. The general requirements for the master’s degree are described under Graduate Education in Part 1. The coherent program of subjects (34 units, though not necessarily all Course 3 subjects) must be approved by the Department Committee on Graduate Students in Course 3. Of the 66 total units required for the master’s degree, 42 graduate degree credits are required to be in Course 3 subjects at graduate H-level. The thesis must have significant materials research content and an internal departmental thesis reader is required if the student’s advisor is outside Course 3. Subjects 3.577 and 3.801, may not be used to satisfy the departmental requirement.
that students earn 42 graduate H-level credits in Course 3 subjects.

The department may also recommend awarding a master’s degree without departmental specification; the general requirements are described under Graduate Education in Part 1. The thesis must be materials-related, and an internal departmental thesis reader is required if the thesis advisor is outside Course 3.

Joint Program with the Technology and Policy Program
The Master of Science in Technology and Policy is an engineering research degree with a strong focus on the role of technology in policy analysis and formulation. The Technology and Policy Program (TPP) curriculum provides a solid grounding in technology and policy by combining advanced subjects in the student’s chosen technical field with courses in economics, politics, and law. Many students combine TPP’s curriculum with complementary subjects to obtain dual degrees in TPP and either a specialized branch of engineering or an applied social science such as political science or urban studies and planning. For additional information, see the program description under Engineering Systems and planning. For additional information, see http://web.mit.edu/tpp/.

Simultaneous Award of Two Master of Science Degrees for Students from Other Departments
Graduate students may seek two Master of Science degrees simultaneously or in sequence, one awarded by the student’s home department and the other by the Department of Materials Science and Engineering. The rules governing dual degrees are found in the section detailing degree requirements under Graduate Education in Part 1. Additional information on requirements that must also be met to obtain the Master of Science degree from the Materials Science and Engineering Department is available from the department.

Entrance Requirements for Graduate Study
General admissions requirements are described under Graduate Education in Part 1. Programs are arranged on an individual basis depending upon the preparation and interests of the student. Those who have not studied some ther-

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**Bachelor of Science in Archaeology and Materials as Recommended by the Department of Materials Science and Engineering/Course 3-C**

**General Institute Requirements (GIRs)**

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory Requirement (can be satisfied by 3.014 or 12.119 in the Departmental Program)</td>
<td>1</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement (can be satisfied by 3.012, 3.021) or 12.001 in the Departmental Program</td>
<td>2</td>
</tr>
<tr>
<td>Science Requirement</td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement (can be satisfied by 3.986, 3.987, 3.985J, and 21A.100; and 3.982, 3.983, or 3.988 in the Departmental Program)</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total GIR Subjects Required for SB Degree</strong></td>
<td>17</td>
</tr>
</tbody>
</table>

**Communication Requirement**
The program includes a Communication Requirement of 4 subjects: 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and 2 subjects designated as Communication Intensive in the Major (CI-M).

**PLUS Departmental Program**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Required Subjects</strong></td>
<td></td>
</tr>
<tr>
<td>3.012 Fundamentals of Materials Science and Engineering, 15, REST; 18.03*</td>
<td>152–162</td>
</tr>
<tr>
<td>3.014 Materials Laboratory, 12, LAB, CI-M</td>
<td></td>
</tr>
<tr>
<td>One of the following three subjects: 3.016 Mathematical Methods for Materials Scientists and Engineers, 12; Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td>18.03 Differential Equations, 12, REST; Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td>18.034 Differential Equations, 12, REST; Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td>One of the following three subjects: 3.022 Introduction to Modeling and Simulation, 12, REST; 18.03*</td>
<td></td>
</tr>
<tr>
<td>1.00 Introduction to Computers and Engineering Problem Solving, 12, REST; Calculus I (GIR)</td>
<td></td>
</tr>
<tr>
<td>6.01 Introduction to EECS I, 12, 1/2 LAB; Physics II (GIR)</td>
<td></td>
</tr>
<tr>
<td>3.022 Microstructural Evolution in Materials, 12; 3.012</td>
<td></td>
</tr>
<tr>
<td>3.032 Mechanical Behavior of Materials, 12; Physics I (GIR), 3.016* or</td>
<td></td>
</tr>
<tr>
<td>3.044 Materials Processing, 12; 3.012, 3.022</td>
<td></td>
</tr>
<tr>
<td>3ThU Thesis, 9†</td>
<td></td>
</tr>
<tr>
<td>3.985J Archaeological Science, 9, HASS-S; Chemistry (GIR)*</td>
<td></td>
</tr>
<tr>
<td>3.986 The Human Past: Introduction to Archaeology, 12, HASS-SF, CI-H</td>
<td></td>
</tr>
<tr>
<td>3.987 Human Origins and Evolution, 9, HASS-S</td>
<td></td>
</tr>
<tr>
<td>3.990 Seminar in Archaeological Method and Theory, 9, CI-M; 3.986, 3.985J, 21A.100</td>
<td></td>
</tr>
<tr>
<td>12.001 Introduction to Geology, 12, REST</td>
<td></td>
</tr>
<tr>
<td>12.119 Analytical Techniques for Studying Environmental and Geologic Samples, 12, LAB</td>
<td></td>
</tr>
<tr>
<td>21A.100 Introduction to Anthropology, 12, HASS-S</td>
<td></td>
</tr>
<tr>
<td><strong>Restricted Electives</strong></td>
<td>21–24</td>
</tr>
<tr>
<td>One subject from the following list: 3.07 Introduction to Ceramics, 12; 3.012</td>
<td></td>
</tr>
<tr>
<td>3.14 Physical Metallurgy, 12; 3.012, 3.022, 3.032</td>
<td></td>
</tr>
<tr>
<td>3.05J Materials for Biomedical Applications, 12; Chemistry (GIR)*</td>
<td></td>
</tr>
<tr>
<td>3.052 Nanomechanics of Materials and Biomaterials, 12; 3.032*</td>
<td></td>
</tr>
<tr>
<td>One subject from the following list: 3.982 The Ancient Andean World, 9, HASS-S</td>
<td></td>
</tr>
<tr>
<td>3.983 Ancient Mesoamerican Civilization, 9, HASS-S</td>
<td></td>
</tr>
<tr>
<td>3.984 Materials in Ancient Societies: Ceramics, 12; permission of instructor</td>
<td></td>
</tr>
<tr>
<td>3.988 Africa—Past and Present: An Archaeological and Ethnographic Materials Perspective, 9, HASS-S</td>
<td></td>
</tr>
<tr>
<td><strong>Departmental Program Units That Also Satisfy the GIRs</strong></td>
<td>(90)</td>
</tr>
<tr>
<td><strong>Unrestricted Electives</strong></td>
<td>97</td>
</tr>
<tr>
<td><strong>Total Units Beyond the GIRs Required for SB Degree</strong></td>
<td>180–193</td>
</tr>
</tbody>
</table>

*No subject can be counted both as part of the 17-subject GIRs and as part of the 180 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.*
Nodynamics and kinetics at the undergraduate level are advised to take 3.012 Fundamentals of Materials and 3.022 Microstructural Evolution.

Requirements for Completion of Graduate Degrees
The general requirements for completion of graduate degrees are also described under Graduate Education in Part 1. Students completing a Master of Science degree are required to present a seminar summarizing the thesis. The department requires that candidates for the doctoral degrees go through a qualifying procedure and pass Institute-mandated general written and oral examinations before continuing with their programs of study and research, and that they satisfy a minor requirement. Information on the qualifying procedure and on the subject areas covered by the general examinations is available from the chair of the Departmental Committee on Graduate Students.

Teaching/Research Assistantships and Fellowships
The Department of Materials Science and Engineering offers assistantships and fellowships for graduate study. Research and teaching assistantships are available in the fields in which the department is active.

Inquiries
Additional information regarding graduate programs, admissions, and financial aid may be obtained by writing to the Academic Office, Room 6-107, 617-253-3302.

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Howard Hughes Medical Investigator
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Adjunct Professor
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Adjunct Professor of Materials Science and Engineering

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Michel Jurgen, PhD

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Harry Vincent Merrick, PhD
Joseph Parse, PhD
Michael J. Tarkanian, PhD
Meri Treska, PhD

Instructor
Peter Houk

Technical Instructor
Sidney W. Carter

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Shyue Ping Ong

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Debabyuti Ghosh
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John M. Maloney
Jifa Qi
Alan Schwartzman
Hyon-Jee Lee Voigt

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George LaBonte

Sponsored Research Technical Staff
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Director, Concourse Program
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John Bruce Vander Sande, PhD
Professor of Material Science, Emeritus
Mechanical engineering is concerned with the responsible development of products, processes, and power, whether at the molecular scale or at the scale of large, complex systems. Mechanical engineering principles and skills are needed at some stage during the conception, design, development, and manufacture of every human-made object with moving parts. Many innovations crucial to our future will have their roots in the world of mass, motion, forces, and energy—the world of mechanical engineers.

Mechanical engineering is one of the broadest and most versatile of the engineering professions. This is reflected in the portfolio of current activities in the department, one that has widened rapidly in the past decade. Today, our faculty are involved in projects ranging from, for example, the use of nanoparticles to tailor the properties of polymers, to the use of nonlinear dynamics to control unsteady flow separation; from the design and fabrication of low-cost radio-frequency identification chips, to the development of efficient methods for robust design; from the development of unmanned underwater vehicles, to the creation of optimization methods that autonomously generate decision-making strategies; from the invention of cost-effective photovoltaic cells, to the prevention of material degradation in proton-exchange membrane fuel cells; from the use of acoustics to explore the ocean of one of Jupiter’s moons, to the biomimetics of swimming fish; from the development of physiological models for the human liver, to the development of novel ways for detecting precancerous events; and from the use of nanoscale antennas for manipulating large molecules, to the fabrication of 3-D nanostructures out of 2-D substrates.

The department carries out its mission with a focus on the seven areas of excellence described below. Our education and research agendas are informed by these areas, and these are the areas in which we seek to impress the best undergraduate and graduate students.

**Area 1: Mechanics: Modeling, Experimentation, and Computation (MMEC).** At the heart of mechanical engineering lies the ability to measure, describe, and model the physical world of materials and mechanisms. The MMEC area focuses on teaching the fundamental principles, essential skills, and scientific tools to be able to predict and understand thermo-mechanical phenomena and use such knowledge in rational engineering design. We provide students with the foundations in experimental, modeling, and computational skills needed to understand, exploit, and enhance the thermo-physical behavior of advanced engineering devices and systems, and to make lifelong creative contributions at the forefront of the mechanical sciences and beyond. Research in the MMEC area focuses on four key thrusts:

- Computational mechanics
- Fluid dynamics
- Mechanics of solid materials
- Nonlinear dynamics

The fundamental engineering principles embodied in these topics can be applied over a vast range of force, time, and length scales, and applications of interest in the MMEC area span the spectrum from the nano/micro world to the geophysical domain. A Course 2-A track is offered in this area.

**Area 2: Design, Manufacturing, and Product Development.** Design, manufacturing, and product development is the complete set of activities needed to bring new devices and technologies to the marketplace. These activities span the entire product life-cycle, from the identification of a market opportunity or need, through design, testing, manufacture and distribution, and end of useful life. Our work includes everything from understanding the voice of the customer to finding new ways of processing materials to improve product performance and tracking product flow through a distribution network. A central component of this area is the design and construction of novel equipment, either for consumer products or for industrial uses. This spans scales from meters to microns, and involves mechanical, electronic and electromechanical devices. Many MechE students apply design, manufacturing, and product development skills and techniques to extracurricular design work for organizations and student activities such as Design that Matters, Formula SAE, Satellite Engineering Team, and the Solar Electric Vehicle Team. Some projects are intended as flagship products for new companies and are entered in the MIT $100K Entrepreneurship Competition. A Course 2-A track in product development is offered along with a unique Master of Engineering degree in manufacturing.

**Area 3: Controls, Instrumentation, and Robotics.** The mission in this area is to promote research and education for automating, monitoring, and manipulating systems. The focus is on system-level behavior that emerges primarily from interactions and cannot be explained from individual component behavior alone. We seek to identify fundamental principles and methodologies that enable systems to exhibit intelligent, goal-oriented behavior, and develop innovative instruments to monitor, manipulate, and control systems. The core competencies in which we seek to excel are:

- Methodologies for understanding system behavior through physical modeling, identification, and estimation
- Technologies for sensors and sensor networks; actuators and energy transducers; and systems for monitoring, processing, and communicating information
- Fundamental theories and methodologies for analyzing, synthesizing, and controlling systems; learning and adapting to unknown environments; and effectively achieving task goals

We seek to apply our core competencies to diverse areas of social, national, and global needs. These include health care, security, education, space and ocean exploration, and autonomous systems in air, land, and underwater. We also offer a Course 2-A track in this area.

**Area 4: Energy Science and Engineering.** Energy is one of the most significant challenges facing humanity and is a central focus of mechanical engineering's contribution to society. Our research focuses on efficient and environmentally friendly energy conversion and utilization from fossil and renewable resources. Programs in the department cover many of the disciplinary and technological aspects of energy, with applications to high performance combustion engines, batteries and fuel cells, thermoelectricity and photovoltaics, wind turbines, and efficient buildings. Work in very-low-temperature thermodynamics includes novel sub-Kelvin refrigeration. Efforts in high-temperature thermodynamics and its coupling with transport and chemistry include internal combustion engine analysis, design, and technology; control of combustion dynamics and emissions; thermo-electric energy conversion; low- and high-temperature fuel cells; and novel materials for rechargeable batteries. Work in heat and mass
transport covers thermal control of electronics from manufacturing to end use; microscale and nanoscale transport phenomena; desalination and water purification; high heat flux engineering; and energy-efficient building technology. Work in renewable energy encompasses the design of offshore and floating wind turbines and tidal wave machines; and analysis and manufacturing of photovoltaic and thermophotovoltaic devices. Energy storage, hybrid systems, fuel synthesis, and integration of energy systems are active research areas in the department. We also offer a Course 2-A track in energy.

Area 5: Ocean Science and Engineering. The oceans cover over 70 percent of the planet’s surface and constitute a critical element in our quality of life, including the climate and the resources and food that we obtain from the sea. This area’s objectives are to support the undergraduate and graduate programs in ocean engineering, including the naval construction program, the MIT/Woods Hole Oceanographic Institution Joint Program in Applied Oceanography and the Course 2-OE degree in mechanical and ocean engineering. It also serves as the focus point of ocean-related research and education at MIT. Major current research activities include marine robotics and navigation of underwater vehicles and smart sensors for ocean mapping and exploration; biomimetics to extract new understanding for the development of novel ocean systems studying marine animals; the study of the mechanics and fluid mechanics of systems for ultradeep ocean gas and oil extraction; ocean wave and offshore wind energy extraction; the free surface hydrodynamics of ocean-going vehicles; the development of advanced naval and commercial ships and submersibles, including the all-electric ship; the mechanics and crashworthiness of ocean ships and structures; ocean transportation systems; ocean acoustics for communication, detection, and mapping in the ocean; and adaptive sampling and multidisciplinary forecasting of the ocean behavior. The design of complex ocean systems permeates all these areas and provides the cohesive link for our research and teaching activities.

Area 6: Bioengineering. Engineering analysis, design, and synthesis are needed to understand biological processes and to harness them successfully for human use. Mechanical forces and structures play an essential role in

### Bachelor of Science in Mechanical Engineering/Course 2

<table>
<thead>
<tr>
<th>General Institute Requirements (GIRs)</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>8</td>
</tr>
</tbody>
</table>

| Restricted Electives in Science and Technology (REST) Requirement [can be satisfied by 2.001 and 18.03 in the Departmental Program] | 2        |

| Laboratory Requirement [can be satisfied by 2.671 in the Departmental Program]                         | 1        |

| Total GIR Subjects Required for SB Degree                                                             | 17       |

<table>
<thead>
<tr>
<th>Communication Requirement</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>The program includes a Communication Requirement of 4 subjects:</td>
<td></td>
</tr>
<tr>
<td>2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and</td>
<td></td>
</tr>
<tr>
<td>2 subjects designated as Communication Intensive in the Major (CI-M) [satisfied by 2.009 and 2.671 in</td>
<td></td>
</tr>
<tr>
<td>the Departmental Program].</td>
<td></td>
</tr>
</tbody>
</table>

| PLUS Departmental Program                                                                            | Units    |
| Subject names below are followed by credit units, and by prerequisites, if any (prerequisites in italics). |          |
| Required Departmental Core Subjects                                                                 | 159      |
| 2.001 Mechanics and Materials I, 12; REST; Physics I (GIR), Calculus II (GIR), 18.03                   |          |
| 2.002 Mechanics and Materials II, 12; 2.001*, Chemistry (GIR)                                       |          |
| 2.003 Dynamics and Control I, 12; REST; Physics I (GIR), 18.03                                        |          |
| 2.004 Dynamics and Control II, 12; 2.001*, Physics II (GIR)                                          |          |
| 2.005 Thermal-Fluids Engineering I, 12; REST; Physics II (GIR), Calculus II (GIR), 18.03              |          |
| 2.006 Thermal-Fluids Engineering II, 12; 2.001*, 18.03                                               |          |
| 2.008 Design and Manufacturing II, 12, 1/2 LAB; 2.001 *                                              |          |
| 2.009 The Product Engineering Process, 12, CI-M; 2.001*, 2.001*, 2.001*, 2.001*, 2.001*, 2.001*, 2.001* |          |
| standing or permission of instructor                                                                 |          |
| 2.016 Numerical Computation for Mechanical Engineers, 12; Physics I (GIR), Calculus II (GIR), 18.03     |          |
| 2.670 Mechanical Engineering Tools, 3*                                                               |          |
| 2.671 Measurement and Instrumentation, 12, LAB, CI-M; 2.001*, 2.001*, 2.001*, 2.001*, 2.001*, 2.001* |          |
| 18.03 Differential Equations, 12, REST; Calculus II (GIR)                                           |          |
| 2.710 Undergraduate Thesis, 6*                                                                         |          |
| and                                                                                                   |          |
| 2.007 Design and Manufacturing I, 12; 2.001*                                                          |          |
| or                                                                                                     |          |
| 2.017 Design of Electromechanical Robotic Systems, 12, 1/2 LAB; 2.001*, 2.001*, 2.001*, 2.001*        |          |
| 2.672 Project Laboratory, 6, 1/2 LAB; 2.001, 2.001, 2.001, 2.001, 2.001                             |          |
| or                                                                                                     |          |
| 2.674 Micro/Nano Engineering Laboratory, 6; 2.001*, 2.001*, 2.001*, 2.001*, 2.001*                  |          |

| Restricted Electives                                                                                    | 24       |
| Students are required to take two of the following elective subjects (substitutions by petition to the  |          |
| MechE Undergraduate Office).                                                                            |          |
| 2.016 Hydrodynamics, 12; Physics II (GIR), 18.03                                                       |          |
| 2.017 Design of Electromechanical Robotic Systems, 12, 1/2 LAB; 2.001*, 2.001*, 2.001*, 2.001*    |          |
| 2.019 Design of Ocean Systems, 12, CI-M; 2.001, 2.001, 2.001, 2.001; senior standing or permission   |          |
| of instructor                                                                                          |          |
| 2.050 Nonlinear Dynamics I: Chaos, 12; 18.03*, Physics II (GIR)                                       |          |
| 2.092 Computer Methods in Dynamics, 12; 2.001, 2.001                                               |          |
| 2.12 Introduction to Robotics, 12; 2.001*                                                           |          |
| 2.14 Analysis and Design of Feedback Control Systems, 12; 2.001*                                     |          |
| 2.141 Biomechanics and Neural Control of Movement, 12; 2.001*                                       |          |
| 2.370 Molecular Mechanics, 12; 2.001*, Chemistry (GIR)                                               |          |
| 2.31 Intermediate Heat and Mass Transfer, 12; 2.001*                                                 |          |
| 2.40 Fundamentals of Advanced Energy Conversion, 12; 2.001*                                          |          |
| 2.711 Optics, 12; Physics II (GIR), 18.03, 2.001*                                                    |          |
| 2.72 Elements of Mechanical Design, 12; 2.001*, 2.001, 2.001, 2.001                                 |          |
| 2.793 Fluids, Forces and Flows in Biological Systems, 12; 2.001*                                    |          |
| 2.793 Molecular, Cellular, and Tissue Biomechanics, 12, 2.370, 18.03                                 |          |
| 2.813 Environmentally Benign Design and Manufacturing, 12; 2.008*                                   |          |
| 2.96 Management in Engineering, 12                                                                  |          |

| Total Required                                                                                       | (36)     |
| Total Unrestricted Electives                                                                           | 48       |

Departmental Program Units That Also Satisfy the GIRs
governing the function of cells, tissues, and organs. Our research emphasizes integration of molecular-to-systems-level approaches to probe the behavior of natural biological systems; and to design and build new systems. At the smallest scale, proteins, enzymes, and biological motors are being studied using instrumentation that combines optical tweezers, single-molecule fluorescence, and pulsed spectroscopy. Single molecules are manipulated within complex systems using nanoscale antennas, opening new avenues for therapy and diagnosis. Computational and experimental models are used to describe the networks of molecules in the cytoskeleton, and how they couple with the extracellular matrix to respond to external forces. Emphasis is also placed on creating new physiological models using the tools of nanomicrofabrication as well as creation of new biomaterials. Applications include understanding, diagnosing, and treating diseases ranging from atherosclerosis to osteoarthritis to liver failure; new tools for drug discovery and drug development; and tissue-engineered scaffolds and devices for in vivo regeneration of tissues and organs. Work also includes design and fabrication of new devices and tools for rehabilitation of stroke victims, and for robotic surgery. We offer many elective subjects as well as a bioengineering track in Course 2-A.

Area 7: Nano/Micro Science and Technology.
The miniaturization of devices and systems of ever-increasing complexity has been a fascinating and productive engineering endeavor during the past few decades. Near and long term, this trend will be amplified as physical understanding of the nano world expands, and widespread commercial demand drives the application of manufacturing to micro- and nanosystems. Micro- and nanotechnology can have tremendous impact on a wide range of mechanical systems. Examples include microelectromechanical system (MEMS) devices and systems that are already deployed as automobile airbag sensors and for drug delivery; stronger and lighter nanostructured materials now used in automobiles; and nanostructured energy conversion devices that significantly improve the efficiency of macroscale energy systems. Research in this area cuts across mechanical engineering and other disciplines. Examples include sensors and actuators; fluids, heat transfer, and energy conversion at the micro- and nanoscales; optical and biological micro- and nano-electromechanical systems (MEMS and NEMS); engineered 3-D nanomaterials; ultraprecision engineering; and the application of optics in measurement, sensing, and systems design. Our faculty members have developed and are developing new educational materials in micro and nano science and technology. Students interested in micro/nano technology are encouraged to explore the Course 2-A nanotechnology track.

In order to prepare the mechanical engineers of the future, the department has developed undergraduate and graduate educational programs of the depth and breadth necessary to address the diverse and rapidly changing technological challenges that society faces. Our educational programs combine the rigor of academic study with the excitement and creativity inherent to innovation and research.

UNDERGRADUATE STUDY

The Department of Mechanical Engineering offers three programs of undergraduate study. The first of these, the traditional program that leads to the bachelor’s degree in mechanical engineering, is a more structured program that prepares students for a broad range of career choices in the field of mechanical engineering. The second program leads to a bachelor’s degree in engineering and is intended for students whose career objectives require greater flexibility. It allows them to combine the essential elements of the traditional mechanical engineering program with study in another, complementary field. The third program, in mechanical and ocean engineering, is also a structured program for students interested in mechanical engineering as it applies to the engineering aspects of ocean science, exploration, and utilization, and of marine transportation.

All of the educational programs in the department prepare students for professional practice in an era of rapidly advancing technology. They combine a strong base in the engineering sciences (mechanics, materials, fluid and thermal sciences, systems and control) with project-based laboratory and design experiences. All strive to develop independence, creative talent, and leadership, as well as the capability for continuing professional growth.

Bachelor of Science in Mechanical Engineering/Course 2

The program in mechanical engineering provides a broad intellectual foundation in the field of mechanical engineering. The program develops the relevant engineering fundamentals, includes various experiences in their application, and introduces the important methods and techniques of engineering practice.

The educational objectives of the program leading to the degree Bachelor of Science in Mechanical Engineering are that: (1) in their careers, graduates will bring to bear a solid foundation in basic mathematical and scientific knowledge and a firm understanding of the fundamental principles and disciplines of mechanical engineering; (2) graduates will use proper engineering principles when they model, measure, analyze, and design mechanical and thermal components and systems; (3) graduates...
Bachelor of Science in Engineering as Recommended by the Department of Mechanical Engineering/Course 2-A

General Institute Requirements (GIRs)  
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>8</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>(can be satisfied by 2.087 in the Departmental Core Subjects and one subject in the Elective Subjects with Engineering Content)</td>
</tr>
<tr>
<td>Laboratory Requirement (satisfied by 2.671 in the Departmental Program)</td>
<td>1</td>
</tr>
</tbody>
</table>

Total GIR Subjects Required for SB Degree  
17

Communication Requirement  
The program includes a Communication Requirement of 4 subjects: 
(1) 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and 
(2) 2 subjects designated as Communication Intensive in the Major (CI-M) (satisfied by 2.009 and 2.671 in the Departmental Program).  

PLUS Departmental Program  
Subject notes below are followed by credit units, and by prerequisites, if any (corequisites in italics).  

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Departmental Core Subjects</td>
<td>96</td>
</tr>
<tr>
<td>First-Level Subjects (60 units)</td>
<td></td>
</tr>
<tr>
<td>2.00 Introduction to Design, 6(1)</td>
<td></td>
</tr>
<tr>
<td>2.01 Elements of Structures, 6; Physics I (GIR), 2.087</td>
<td></td>
</tr>
<tr>
<td>2.087 Engineering Mathematics: Linear Algebra and ODEs, 12, REST; Calculus II (GIR), Physics I (GIR), 2.090</td>
<td></td>
</tr>
<tr>
<td>2.090 Engineering Mathematics: Probability and Statistics, 6; Calculus II (GIR), Physics I (GIR)</td>
<td></td>
</tr>
<tr>
<td>2.03 Dynamics, 6; 2.087</td>
<td></td>
</tr>
<tr>
<td>2.05 Thermodynamics, 6; 2.087</td>
<td></td>
</tr>
<tr>
<td>2.053 Introduction to Heat Transfer, 6; 2.05</td>
<td></td>
</tr>
<tr>
<td>2.06 Fluid Dynamics, 6; 2.01</td>
<td></td>
</tr>
<tr>
<td>2.678 Electronics for Mechanical Systems, 6; Physics II (GIR)</td>
<td></td>
</tr>
<tr>
<td>Second-Level Subjects (36 units)</td>
<td></td>
</tr>
<tr>
<td>2.009 The Product Engineering Process, 12, CI-M; 2.01*, 2.03*, 2.05*, 2.670*; senior standing or permission of instructor</td>
<td></td>
</tr>
<tr>
<td>2.671 Measurement and Instrumentation, 12, LAB, CI-M; 2.01*, 2.03*, Physics II (GIR)</td>
<td></td>
</tr>
<tr>
<td>2.024 Mechanics of Materials: Properties and Applications, 6; 2.01</td>
<td></td>
</tr>
<tr>
<td>or 2.026 Mechanics of Structures, 6; 2.01</td>
<td></td>
</tr>
<tr>
<td>2.044 Systems and Controls, 6; 2.03</td>
<td></td>
</tr>
<tr>
<td>or 2.048 Introduction to Mechanical Vibration, 6; 2.03</td>
<td></td>
</tr>
<tr>
<td>Elective Subjects with Engineering Content(2)</td>
<td>72</td>
</tr>
<tr>
<td>(Must include one REST subject outside Course 2.)</td>
<td></td>
</tr>
<tr>
<td>Departmental Program Units That Also Satisfy the GIRs</td>
<td>36</td>
</tr>
<tr>
<td>Unrestricted Electives</td>
<td>48</td>
</tr>
<tr>
<td>Total Units Beyond the GIRs Required for SB Degree</td>
<td>180</td>
</tr>
</tbody>
</table>

No subject can be counted both as part of the 17-subject GIRs and as part of the 180 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

Notes  
* Alternate prerequisites and corequisites are listed in the subject description.  
(1) Students who have completed a subject that provides equivalent experience (e.g., 2.008) may petition to substitute; contact the MechE Undergraduate Office, Room 1210, for information.  
(2) These electives define a concentrated area of study and must be chosen with the written approval of the MechE Undergraduate Office. The 72 units of concentration electives must be engineering topics. Concentration electives must include one subject that meets the REST GIR, but not subjects that fulfill a HASS GIR. Engineering topics are usually obtained from engineering courses, but in some cases, non-engineering subjects may be necessary for the particular engineering program defined by the concentration (e.g., management subjects for an engineering management concentration). In all cases, the relationship of concentration subjects to the theme of the concentration must be obvious. For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.

Bachelor of Science in Engineering as Recommended by the Department of Mechanical Engineering/Course 2-A

Course 2-A is designed for students whose academic and career goals demand greater breadth and flexibility than are allowed under the mechanical engineering program, Course 2. To a large extent, the 2-A program allows students an opportunity to tailor a curriculum to their own needs, starting from a solid mechanical engineering base. The program combines a rigorous grounding in core mechanical engineering topics with an individualized course of study focused on a second area that the student designs with the help and approval of the 2-A faculty advisor. The program leads to the degree Bachelor of Science in Engineering as Recommended by the Department of Mechanical Engineering.

This curriculum has been accredited by the Accreditation Board for Engineering and Technology as an engineering degree.

The educational objectives of the program leading to the degree of Bachelor of Science in Engineering as recommended by the Department of Mechanical Engineering are that: (1) in their careers, graduates will bring to bear a solid foundation in basic mathematical and scientific knowledge and a firm understanding of the basic principles and disciplines of mechanical engineering; (2) graduates will use proper engineering principles when they model, measure, analyze, and design engineering
systems, processes, and components; (3) graduates will have the professional skills necessary for formulating and executing design projects, for teamwork, and for effective communication; (4) graduates will demonstrate the confidence, awareness of societal context, professional ethics, and motivation for lifelong learning that are necessary for them to be leaders in their chosen fields of endeavor; and (5) graduates will integrate mechanical engineering technical abilities and knowledge with those of another disciplinary field.

A significant part of the 2-A curriculum consists of electives chosen by the student to provide in-depth study of a field of the student’s choosing. A wide variety of popular concentrations are possible in which well-selected academic subjects complement a foundation in mechanical engineering and general Institute requirements. Some examples of potential concentrations include robotics, engineering management, product development, biomedical engineering and pre-medicine, energy conversion engineering, sustainable development, architecture and building technology, and any of the seven departmental focus areas mentioned above. The MechE faculty have developed specific recommendations in some of these areas; details are available from the MechE Undergraduate Office and on the departmental website.

Concentrations are not limited to those listed above. Students are encouraged to design and propose technically oriented concentrations that reflect their own needs and those of society.

The student’s overall program must contain a total of at least one and one-half years of engineering content (144 units) appropriate to the student’s field of study. The required core and second-level subjects include approximately 75 units of engineering topics. The self-designed concentration must include at least 69 more units of engineering topics. While engineering topics are usually covered through engineering subjects, subjects outside the School of Engineering may provide material essential to the engineering program of some concentrations. For example, management subjects usually form an essential part of an engineering management concentration. In all cases, the relationship of concentration subjects to the particular theme of the concentration must be obvious.

### Bachelor of Science in Mechanical and Ocean Engineering/Course 2-OE

<table>
<thead>
<tr>
<th>General Institute Requirements (GIRs)</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>[can be satisfied by 2.001 and 18.03 in the Departmental Program]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>[can be satisfied by 2.671 in the Departmental Program]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total GIR Subjects Required for SB Degree</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Communication Requirement</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>The program includes a Communication Requirement of 4 subjects:</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 subjects designated as Communication Intensive in the Major (CI-M) [satisfied by 2.019 and 2.671 in the Departmental Program].</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PLUS Departmental Program</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).</td>
<td>147</td>
<td></td>
</tr>
<tr>
<td>Required Departmental Subjects</td>
<td>147</td>
<td></td>
</tr>
<tr>
<td>2.001 Mechanics and Materials I, 12, REST; Physics I (GIR), Calculus II (GIR), 18.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.002 Mechanics and Materials II, 12; 2.001*, Chemistry (GIR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.003 Dynamics and Control I, 12, REST; Physics I (GIR), 18.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.004 Dynamics and Control II, 12; 2.003*, Physics II (GIR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.005 Thermal-Fluids Engineering I, 12; REST; Physics II (GIR), Calculus II (GIR), 18.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.006 Hydrodynamics, 12; Physics II (GIR), 18.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.017 Design of Electromechanical Robotic Systems, 12, 1/2 LAB; 2.003*, 2.005*, 2.671</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.019 Design of Ocean Systems, 12, CI-M; 2.001, 2.003J, 2.005*; senior standing or permission of instructor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.086 Numerical Computation for Mechanical Engineers, 12; Physics I (GIR), Calculus II (GIR), 18.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.612 Marine Power and Propulsion, 12; 2.005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.670 Mechanical Engineering Tools, 3**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.671 Measurement and Instrumentation, 12, LAB, CI-M; 2.001*, 2.003*, Physics II (GIR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.03 Differential Equations, 12, REST; Calculus II (GIR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restricted Electives</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Students are required to take two of the following elective subjects (substitutions by petition to the MechE Undergraduate Office):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.006 Thermal Fluids Engineering II, 12; 2.005*, 18.03*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.007 Design and Manufacturing I, 12; 2.001*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.008 Design and Manufacturing II, 12, 1/2 LAB; 2.007*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.009 Acoustics and Sensing, 12; 2.003J*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.092 Computer Methods in Dynamics, 12; 2.001*, 2.003J*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.11 Introduction to Robotics, 12; 2.004*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.14 Analysis and Design of Feedback Control Systems, 12; 2.004*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.30 Intermediate Heat and Mass Transfer, 12; 2.006*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.60 Fundamentals of Advanced Energy Conversion, 12; 2.006*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.700 Principles of Naval Architecture, 12; 2.002*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.72 Elements of Mechanical Design, 12; 2.005*, 2.007, 2.671</td>
<td></td>
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</tr>
<tr>
<td>2.76 Management in Engineering, 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.7Hu Undergraduate Thesis, 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Departmental Program Units That Also Satisfy the GIRs</td>
<td>(96)</td>
<td></td>
</tr>
<tr>
<td>Unrestricted Electives</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Total Units Beyond the GIRs Required for SB Degree</td>
<td>183</td>
<td></td>
</tr>
</tbody>
</table>

No subject can be counted both as part of the 17-subject GIRs and as part of the 183 units required beyond the GIRs. Every subject in the student’s Departmental Program will count toward one or the other, but not both.

**Notes**

* Alternate prerequisites and corequisites are listed in the subject description.

** Students may fulfill this requirement by completing a subject that provides equivalent experience (e.g., 2.008 or 2.670); consult the MechE Undergraduate Office, Room 1-110, for information.

For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, [http://student.mit.edu/catalog/index.cgi](http://student.mit.edu/catalog/index.cgi).
To pursue the 2-A degree, students must submit the online 2-A enrollment form no later than Add Date of their second term in the program. The online enrollment form is available at https://meche.mit.edu/resources/2A/ (MIT certificate is required).

Bachelor of Science in Mechanical and Ocean Engineering/Course 2-OE
This program is intended for students who are interested in combining a firm foundation in mechanical engineering with a specialization in ocean engineering. The program includes engineering aspects of the ocean sciences, ocean exploration, and utilization of the oceans for transportation, defense, and extracting resources. Theory, experiment, and computation of ocean systems and flows are covered in a number of subjects, complementing a rigorous mechanical engineering program; a hands-on capstone design class allows students to master the design of advanced marine systems, including autonomous underwater vehicles and smart sensors.

This curriculum has been accredited by the Accreditation Board for Engineering and Technology in both mechanical engineering and ocean engineering.

The educational objectives of the program leading to the degree Bachelor of Science in Mechanical and Ocean Engineering are that: (1) in their careers, graduates will bring to bear a solid foundation in basic mathematical and scientific knowledge and a firm understanding of the fundamental principles and disciplines of both mechanical and ocean engineering; (2) graduates will use proper engineering principles when they model, measure, analyze, and design mechanical, thermal, and ocean components and systems; (3) graduates will have the professional skills necessary for formulating and executing design projects, for teamwork, and for effective communication; and (4) graduates will demonstrate the confidence, awareness of societal context, professional ethics, and motivation for lifelong learning that are necessary for them to be leaders in their chosen fields of endeavor.

Graduates have exciting opportunities in offshore industries, naval architecture, the oceanographic industry, the Navy, or government, or for further study in graduate school.

Undergraduate Practice Opportunities Program
The Undergraduate Practice Opportunities Program, an innovative internship program administered and sponsored by the School of Engineering, offers opportunities to sophomores in the School. Further information on the program may be obtained from the department in which the student is registered or from Susann Luperfoy, executive director, Room 12-193, 617-253-0055, upop@mit.edu, or from http://web.mit.edu/engineering/upop/.

Minor in Mechanical Engineering
Students pursuing a minor in the department must complete a total of six 12-unit subjects in the Mechanical Engineering Department program (including 18.03 as a prerequisite to departmental subjects). Subjects for the minor must constitute a coherent program approved by the department, and be drawn from the required subjects and departmental electives in the Course 2 or Course 2-OE degree programs. These subjects must include four of the MechE program’s required core subjects.

Inquiries
Further information on undergraduate programs may be obtained from the MechE Undergraduate Office, Room 1-110, 617-253-2305, me-undergradoffice@mit.edu, and from the downloadable Guide to the Undergraduate Program in Mechanical Engineering (http://web.mit.edu/me-ugoffice/gamed.pdf).

GRADUATE STUDY
The Mechanical Engineering Department provides opportunities for graduate work leading to the following degrees: Master of Science in Mechanical Engineering, Master of Science in Ocean Engineering, Master of Science in Naval Architecture and Marine Engineering, Master of Science in Oceanographic Engineering, Master of Engineering in Manufacturing, degree of Mechanical Engineer, degree of Naval Engineer, and the Doctor of Philosophy (PhD) or Doctor of Science (ScD), which differ in name only.

The Master of Engineering in Manufacturing degree is a 12-month professional degree intended to prepare students for technical leadership in the manufacturing industries.

The Mechanical Engineer’s and Naval Engineer’s degrees offer preparation for a career in advanced engineering practice through a program of advanced coursework that goes well beyond the master’s level. These degrees are not a stepping stone to the PhD.

The Doctor of Philosophy (or Science), the highest academic degree offered, is awarded upon the completion of a program of advanced study and significant original research, design, or development.

Entrance Requirements for Graduate Study
Applications to the mechanical engineering graduate program are accepted from persons who have completed, or will have completed by the time they arrive, a bachelor’s degree if they are applying for a master’s degree, or a master’s degree if they are applying for a PhD. Most incoming students have a degree in mechanical engineering or ocean engineering, or some related branch of engineering. The department’s admission criteria are not specific, however, and capable students with backgrounds in different branches of engineering or in science may gain entry. Nevertheless, to qualify for a graduate degree, the candidate is expected to have had at least an undergraduate-level exposure to the core subject areas in mechanical engineering (applied mechanics, dynamics, fluid mechanics, thermodynamics, materials, control systems, and design) and to be familiar with basic electrical circuits and electromagnetic field theory.

Applications for September entry are due on December 15 of the previous year (except for the Master of Engineering in Manufacturing, which has a January 15 deadline), and decisions are reported in March. International students applying from abroad may be admitted, but they will be allowed to register only if they have full financial support for the first year.

All applicants to the graduate program in mechanical engineering must submit the GRE test results. International students whose native language is not English are required to take the International English Language Testing System (IELTS) exam and receive a minimum score of 7 or the TOEFL exam with a minimum acceptable score of 577 (PBT), 233 (CBT) or 90 (iBT).
Early Admission to Master's Degree Programs in Mechanical Engineering
At the end of the junior year, extraordinarily qualified students in the Department of Mechanical Engineering will be invited to apply for early admission to the graduate program. Students who are admitted will then be able to enroll in core graduate subjects during the senior year and to find a faculty advisor who is willing to start and supervise research for the master's thesis while the student is still in the senior year. With the consent of the faculty advisor, the student may also use a portion of the work conducted towards the master's thesis in the senior undergraduate year to satisfy the requirements of the bachelor's thesis.

Writing Ability Requirement
The Mechanical Engineering Department requires that all incoming graduate students demonstrate satisfactory English writing ability, or successfully complete appropriate training in writing. This requirement reflects the faculty's conviction that writing is an essential skill for all engineers. All incoming graduate students, native as well as international, must take the departmental writing ability test, which is administered online in August. Depending on the results, a student will either pass or be required to take a short course during the Independent Activities Period (January).

Master of Science in Mechanical Engineering
To qualify for the Master of Science in Mechanical Engineering, a student must complete at least 72 credits of coursework, not including thesis. Of these, at least 48 must be graduate H-level subjects (refer to the Guide to Graduate Study on the MechE website). The remainder of the 72 units may be for G-level subjects or advanced undergraduate subjects that are not requirements in the undergraduate mechanical engineering curriculum.

At least three of the H-level subjects must be taken in mechanical engineering sciences (refer to the Guide to Graduate Study on the MechE website). Students must take at least one graduate mathematics subject (12 units) offered by the MIT Mathematics Department. No waivers are allowed. For the Master of Science in Oceanographic Engineering see also the requirements listed in the Joint Program with Woods Hole Oceanographic Institution.

Finally, a thesis is required. The thesis is an original work of research, development, or design, performed under the supervision of a faculty or research staff member, and is a major part of any graduate program in the Mechanical Engineering Department. A master's student usually spends as much time on thesis work as on coursework. A master's degree usually takes about one and one-half to two years to complete.

Master of Science in Ocean Engineering/Master of Science in Naval Architecture and Marine Engineering/Master of Science in Oceanographic Engineering
The requirements for each of these three degrees are that the student takes 72 credit units of graduate subjects—48 of which must be H-level subjects—and complete a thesis.

At least three of the subjects must be chosen from a prescribed list of ocean engineering subjects (refer to the Guide to Graduate Study on the MechE website). Students must also take at least one graduate mathematics subject (12 units) offered by MIT's Mathematics Department. For the Master of Science in Oceanographic Engineering, see also the requirements listed under the Joint Program with Woods Hole Oceanographic Institution.

The required thesis is an original work of research, development, or design, conducted under the supervision of a faculty or senior research staff member. The thesis usually takes between one and two years to complete.

Leaders for Global Operations Program
The 24-month Leaders for Global Operations (LGO) program combines graduate education in engineering and management for those with two or more years of full-time work experience who aspire to leadership positions in manufacturing or operations companies. A required six-month internship comprising a research project at one of LGO's partner companies leads to a dual-degree thesis, culminating in two master's degrees—an MBA (or SM in management) and an SM from Aeronautics and Astronautics. The program is offered jointly through the MIT Sloan School of Management and the School of Engineering. For more information, visit http://lgo.mit.edu/ or see the program description under Engineering Systems Division.

Mechanical Engineer's Degree
The Mechanical Engineer's degree provides an opportunity for further study beyond the master's level for those who wish to enter engineering practice rather than research. This degree emphasizes breadth of knowledge in mechanical engineering and its economic and social implications, and is quite distinct from the PhD, which emphasizes depth and originality of research. The engineer's degree requires a broad program of advanced coursework in mechanical engineering totaling at least 162 credit units (typically about 14 subjects), including those taken during the master's degree program. The engineer's degree program is centered around the application of engineering principles to advanced engineering problems and includes a Mechanical Engineering examination and an applications-oriented thesis, which may be an extension of a suitable master's thesis. An engineer's degree typically requires at least one year of study beyond the master's degree.
Naval Engineer’s Degree—Program in Naval Construction and Engineering
The Naval Construction and Engineering (NVE) program provides US Navy and US Coast Guard officers, foreign naval officers, and civilian students interested in ships and ship design a broad graduate-level education for a career as a naval engineer.

The program leads to the Naval Engineer’s degree, which requires a higher level of professional competence and broader range of knowledge than is required for the degree of Master of Science in Naval Architecture and Marine Engineering or Ocean Engineering. Subjects in the areas of economics, industrial management, and public policy and law, and at least 12 units of comprehensive design are required, in addition to an in-depth curriculum that includes naval architecture, hydrodynamics, ship structures, materials science, and power and propulsion. The program is appropriate for naval officers and civilians who plan to participate in the design and construction of naval ships, as well as those interested in commercial ship design.

For students working toward a simultaneous Naval Engineer’s degree and a master’s degree, a single thesis is generally acceptable, provided it is appropriate to the specifications of both degrees, demonstrating an educational maturity expected of the Naval Engineer’s degree.

Doctor of Philosophy and Doctor of Science
The highest academic degree is the Doctor of Science, or Doctor of Philosophy (the two differ only in name). This degree is awarded upon the completion of a program of advanced study, and the performance of significant original research, design, or development. Doctoral degrees are offered in all areas represented by the department’s faculty.

Students become candidates for the doctoral by passing the doctoral qualifying examinations. The doctoral program includes a major program of advanced study in the student’s principal area of interest, and a minor program of study in a different field. The MechE Graduate Office should be consulted about the deadline for passing the qualifying exam.

The principal component of the program is the thesis. The thesis is a major, original work that makes a significant research, development, or design contribution in its field. The thesis and the program of study are done under a faculty supervisor and a doctoral committee selected by the student and his or her supervisor, and perhaps other interested faculty members. The committee makes an annual examination of the candidate’s progress and conducts a final examination based on the thesis. The doctoral program usually takes a minimum of two years of work beyond the master’s degree.

Interdisciplinary Programs
Graduate students registered in the Department of Mechanical Engineering may elect to participate in interdisciplinary programs of study. Programs are available in computation for design and optimization, polymer science and technology, and technology and policy. See Interdisciplinary Graduate Programs in Part 3 for program descriptions.

Joint Program with the Woods Hole Oceanographic Institution
The Joint Program with the Woods Hole Oceanographic Institution (2W) is intended for students whose primary career objective is oceanographic engineering. Students divide their academic and research efforts between the campuses of MIT and WHOI, Joint Program students are assigned an MIT faculty member as academic advisor; however, thesis research may be supervised by MIT or WHOI faculty. While in residence at MIT, students follow a program similar to that of other students in the department. The program is described in more detail under Interdisciplinary Graduate Programs in Part 3.

Assistantships and Fellowships
The Department of Mechanical Engineering offers three types of financial assistance to graduate students: research assistantships, teaching assistantships, and fellowships.

The majority of students in the department are supported by research assistantships (RAs), which are appointments to work on particular research projects with particular faculty members. Faculty members procure research grants for various projects and hire graduate students to carry out the research. The research is almost invariably structured so that it becomes the student’s thesis. An RA appointment provides a full-tuition scholarship (i.e., covers all tuition) plus a salary that is adequate for a single person. The financial details are outlined in a separate handout available from the MechE Graduate Office. An RA may register for a maximum of 24 units (about two subjects) of classroom subjects per regular term and 12 units in the summer term, and must do at least the equivalent of 24 units of thesis (i.e., research on the project) per term. (Please note that Master of Engineering in Manufacturing students are not eligible for RA or TA positions since their subject credits exceed these limits.)

Teaching assistants (TAs) are appointed to work on specific subjects of instruction. As the name implies, they usually assist a faculty member in teaching, often grading homework problems and tutoring students. In the Mechanical Engineering Department, TAs are very seldom used for regular full-time classroom teaching. TAs are limited to 24 units of credit per regular term, including both classroom subjects and thesis. The TA appointment does not usually extend through the summer.

A fellowship provides the student with a direct grant, and leaves the student open to select his or her own research project and supervisor. A limited number of awards and scholarships are available to graduate students directly through the department. A number of students are also supported by fellowships from outside agencies, such as the National Science Foundation, Office of Naval Research, and Department of Defense. Scholarships are awarded each year by the Society of Naval Architects and Marine Engineers. These awards are normally granted to applicants whose interest is focused on naval architecture and marine engineering or on ocean engineering. Applications are made directly to the granting agency, and inquiries for the fall term should be made in the preceding fall term.

Prospective students are invited to communicate with the department regarding any of these educational and financial opportunities.

Experience has shown that the optimum graduate program consists of about equal measures of coursework and research, consistent with an RA appointment. The main advantage of a fellowship is a greater freedom in choosing a research project and supervisor. A teaching assistantship gives the student teaching experience and can also be extremely valuable for reviewing basic subject material—for example,
in preparation for the doctoral qualifying exams. It does not, however, leave much time for thesis research and may extend the time that the student needs to complete his or her degree.

Inquiries
For additional information on mechanical engineering graduate admissions, contact Joan Kravit or Una Sheehan. For general inquiries on the mechanical engineering graduate program, contact Leslie Regan. All can be reached in the MechE Graduate Office, Room 1-112, 617-253-2291, me-gradoffice@mit.edu.

RESEARCH LABORATORIES AND PROGRAMS

The Mechanical Engineering Department is organized into seven areas that collectively capture the broad range of interests and activities within it. These areas are:

- Mechanics: Modeling, Experimentation, and Computation (MMEC)
- Design, Manufacturing, and Product Development
- Controls, Instrumentation, and Robotics
- Energy Science and Engineering
- Ocean Science and Engineering
- Bioengineering
- Nano/Micro Science and Technology

The educational opportunities offered to students in mechanical engineering are enhanced by the availability of a wide variety of research laboratories and programs, and well-equipped shops and computer facilities.

The department provides many opportunities for undergraduates to establish a close relationship with faculty members and their research groups. Students interested in project work are encouraged to consult their faculty advisor or approach other members of the faculty.

Many members of the Department of Mechanical Engineering participate in interdepartmental or school-wide research activities. These include the Center for Biomedical Engineering, Center for Computational Engineering, Center for Materials Science and Engineering, Computation for Design and Optimization Program, Computational and Systems Biology Program, Computer Science and Artificial Intelligence Laboratory, Institute for Soldier Nanotechnologies, Laboratory for Manufacturing and Productivity, MIT Energy Initiative, Operations Research Center, Program in Polymer Science and Technology and Sea Grant College Program. Detailed information about many of these can be found under Interdisciplinary Research and Study and Interdisciplinary Graduate Programs in Part 3. The department also hosts a number of industrial consortia, which support some laboratories and research projects. Research in the department is supported, in addition, by a broad range of federal agencies and foundations.

Below is a partial list of departmental laboratories, listed according to the seven core areas of research.

Mechanics: Modeling, Experimentation, and Computation

AMP Mechanical Behavior of Materials Laboratory
Mechanisms of deformation and fracture processes in engineering materials.

Center for Nonlinear Science
Interdisciplinary research into nonlinear phenomena. Incorporates the Nonlinear Dynamical Systems Lab (modeling, simulation, analysis), Nonlinear Dynamics Lab (experiments), and Nonlinear Systems Lab.

Composite Materials and Nondestructive Evaluation Laboratory
Development of quantitative nondestructive evaluation characterizations which are directly correlatable with the mechanical properties of materials and structures.

Finite Element Research Group
Computational procedures for the solution of problems in structural, solid, and fluid mechanics.

Hatsopoulos Microfluids Laboratory
Fundamental research on the behavior of complex fluid systems at microscopic scales, and associated engineering applications.

Design, Manufacturing, and Product Development

Auto-ID Laboratory
Creation of the “Internet of Things” using radio frequency identification and wireless sensor networks, and of a global system for tracking goods using a single numbering system called the Electronic Product Code.

Computer-Aided Design Laboratory
Advancing the state of the art in design methodology and computer-aided design methods.

Laboratory for Manufacturing and Productivity
An interdepartmental laboratory in the School of Engineering. Polymer microfabrication for microfluidic devices, chemical mechanical planarization for the semiconductor industry, precision macro- and micro-scale devices, and novel metrology methods for micro-scale devices. Small-scale fuel cells design, photovoltaic material and process research, and manufacture of photovoltaic panels. Identification technologies such as RFID, wireless sensors, and complex systems. Methods to integrate data and models across global networks. Factory-level manufacturing systems design and control, and supply chain design and management. Environmentally benign manufacturing.

Martin Center for Engineering Design
Design methodology, design of integrated electrical-mechanical systems, prototype development, advanced computer-aided design techniques.

Park Center for Complex Systems
Research to understand complexity, educating students and scholars on complexity, designing complex systems for the benefit of humankind, and disseminating knowledge on complexity to the world at large.

Precision Engineering Laboratory
Fundamental and applied research on all aspects of the design, manufacture, and control of high precision machines ranging from manufacturing machines to precision consumer products.

Precision Systems Design and Manufacturing Laboratory
Modeling, design, and manufacturing methods for nanopositioning equipment, carbon
nanotube-based mechanisms and machines, and compliant mechanisms.

**Controls, Instrumentation, and Robotics**

*d’Arbeloff Laboratory for Information Systems and Technology*
Research on mechatronics, home and health automation, interface between hardware and software, and development of sensing technologies.

**Field and Space Robotics Laboratory**
Fundamental physics of robotic systems for unstructured environments. Development, design, and prototyping of control and planning algorithms for robotic applications, including space exploration, rough terrains, sea systems, and medical devices and systems.

**Nonlinear Systems Laboratory**
Analysis and control of nonlinear physical systems with emphasis on adaptation and learning in robots.

**Energy Science and Engineering**

**Center for Energy and Propulsion Research**
Innovative science and technology for a sustainable energy future in a carbon-constrained world. Fundamental and applied research in energy conversion and transportation, with applications to low-carbon efficient energy and propulsion systems. Includes several research groups:

- **Electrochemical Energy Laboratory.** Engineering of advanced materials for lithium batteries, proton exchange membrane and solid oxide fuel cells, and air battery and fuel cell hybrids.
- **Reacting Gas Dynamics Laboratory.** Fluid flow, chemical reaction, and combustion phenomena associated with energy conversion in propulsion systems, power generation, industrial processes, and fires.
- **Sloan Automotive Laboratory.** Processes and technology that control the performance, efficiency, and environmental impact of internal combustion engines, their lubrication, and fuel requirements.

**Cryogenic Engineering Laboratory**
Application of thermodynamics, heat transfer, and mechanical design to cryogenic processes and instrumentation and the operation of a liquid helium facility.

**Rohsenow Kendall Heat Transfer Laboratory**
Fundamental research in microscale/nanoscale transport, convection, laser/material interaction, and high heat fluxes; applied research in water purification, thermoelectric devices, energy-efficient buildings, and thermal management of electronics.

**Ocean Science and Engineering**

**Center for Ocean Engineering**
Provides an enduring ocean engineering identity, giving visibility to the outside world of MIT’s commitment to the oceans, and serves as the focus point of ocean-related research at the Institute. Supports the research activities of the MIT/WHOI Joint Program in Oceanographic Engineering and the Naval Construction and Engineering Program. Encompasses the activities of the following research groups and laboratories:

- **Autonomous Marine Sensing Lab.** Distributed ocean sensing concepts for oceanographic science, national defense, and coastal management and protection. Oceanographic sensing and modeling, sonar system technology, computational underwater acoustics, and marine robotics and communication networking.
- **Design Lab.** Ship design, offshore structure design, marine robotics, geometric and solid modeling, advanced manufacturing, and shipbuilding. Includes the Center for Environmental Sensing and Modeling.
- **Experimental Hydromechanics Lab.** Advanced surface ship, offshore platform, and under-water vehicle design. Development of non-invasive flow measurement and visualization methods.
- **Impact and Crashworthiness Laboratory.** Industry-oriented fracture testing and prediction technology of advanced high-strength steel sheets for automotive and shipbuilding applications. Includes both quasi-static and high strain rate response and effect of loading history on fracture.
- **Experimental and Nonlinear Dynamics Lab.** Laboratory experiments to obtain insight into all manner of dynamical phenomena, from micro-scale diffusive processes to global-scale oceanic wave fields. Field studies for ocean-related problems.
- **Laboratory for Ship and Platform Flows.** Modeling of free surface flows past conventional and high-speed vessels and estimation of their resistance and seakeeping in deep and shallow waters. Analytical and computational techniques.
- **Laboratory for Undersea Remote Sensing.** Ocean exploration, undersea remote sensing of marine life and geophysical phenomena, wave propagation and scattering theory in remote sensing, statistical estimation and information theory, acoustics and seismics, Europa exploration.
- **Marine Hydrodynamics Laboratory (Propeller Tunnel).** A variable-pressure recirculating water tunnel capable of speeds up to 10 m/s. Experiments are performed using state-of-the-art measurement techniques and instrumentation.
- **Multidisciplinary Ocean Dynamics and Engineering Laboratory.** Complex physical and interdisciplinary oceanic dynamics and processes. Mathematical model and computation methods for ocean predictions, dynamical diagnostics, and for data assimilation and data-model comparisons.
- **Ocean Engineering Testing Tank.** The tank is 108 feet long, 8.5 feet wide, with an average depth of 4.5 feet. The wave generator can generate harmonic or random waves. The tank also houses several laser flow visualization systems.
- **Vertical Flow Research Laboratory.** Advanced capabilities for simulation of complex vertical flows. Powerful computer workstations and LINUX clusters, computer-video image conversion, and state-of-the-art flow simulation animation technologies.
- **MIT Sea Grant AUV Lab.** Dedicated to autonomous underwater vehicles (AUVs), the lab is a leading developer of advanced unmanned marine robots, with applications in oceanography, environmental monitoring, and underwater resource studies. It engages in instrumentation and algorithm development for underwater vehicles performing
navigation- and information-intensive tasks. Various vehicle platforms, and fabrication tools and materials are available.

Bioengineering

Bioinstrumentation Laboratory
Utilization of biology, optics, mechanics, mathematics, electronics, and chemistry to develop innovative instruments for the analysis of biological processes and new devices for the treatment and diagnosis of disease.

Human and Machine Haptics
Interdisciplinary studies aimed at understanding human haptics, developing machine haptics, and enhancing human-machine interactions in virtual reality and teleoperator systems.

International Consortium for Medical Imaging Technology
Development and implementation of information technology that will lead to improved medical diagnosis and health care as well as reductions in costs.

Laboratory for Biomechanics of Cells and Biomolecules
Development of new instruments for the measurement of mechanical properties on the scale of a single cell or single molecule to better understand the interactions between biology and mechanics.

Newman Laboratory for Biomechanics and Human Rehabilitation
Research on bioinstrumentation, neuromuscular control, and technology for diagnosis and remediation of disabilities.

Nano/Micro Science and Technology

Pappalardo Laboratory for Micro/Nano Engineering
Creation of new engineering knowledge and products on the nano and micro scale through multidomain, multidisciplinary, and multiscale research.

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The Department of Nuclear Science and Engineering provides undergraduate and graduate education for students interested in developing new nuclear technologies for the benefit of society and the environment and in advancing the intellectual frontiers of the field.

This is an exciting time to study nuclear science and engineering. There is an upsurge of innovative activity in the field, as energy resource constraints, energy security concerns, and the risks of climate change are creating new demands for safe, secure, cost-competitive nuclear energy systems. At the same time, new tools for exploring, modeling and controlling complex nuclear and radiation processes are laying the foundations for major advances in the application of nuclear technologies in medicine and industry.

In response to these developments, the department has developed programs of study that prepare students for technical leadership roles in energy and non-energy applications of nuclear science and technology. Applications include nuclear fission energy systems, fusion energy systems, and systems for securing nuclear materials against the threats of nuclear proliferation and terrorism. Underlying these applications are core fields of education and research, including: low-energy nuclear physics; plasma physics; radiation sources, detection, and control; the study of materials in harsh chemo-mechanical, radiation, and thermal environments; and advanced computation and simulation.

Students in nuclear science and engineering study the scientific fundamentals of the field, engineering methods for integrating these fundamentals into practical systems, and the interactions of nuclear systems with society and the environment. Undergraduate and graduate students take core subjects in the field and can then select from a wide variety of application areas through more specialized subjects.

Principal areas of research and education in the department are described below.

**Nuclear Fission Energy.** Nuclear reactors, using the fissioning of heavy elements such as uranium, supply approximately 16% of the world’s electricity and power ships and submarines. They produce radioisotopes for medical, biological, and industrial uses, and for long-lived onboard power sources for spacecraft. They can also provide energy for chemical and industrial processing and portable fuel production (e.g., synthetic fuels or hydrogen.)

Electricity generation is the most familiar application. In some countries, the fraction of electricity obtained from nuclear power exceeds 50%. In the United States, more than 100 nuclear power plants supply 20 percent of the nation’s electricity. Thirty countries generate nuclear power today, and more than 50 others have recently expressed an interest in developing new nuclear energy programs. Nuclear power is the only low-carbon energy source that is both inherently scalable and already generating a significant share of the world’s electricity supplies. Fission technology is today entering a new era in which upgraded existing plants, new-generation reactors, and new fuel cycle technologies and strategies will contribute to meeting the rapidly growing global demand for safe and cost-competitive low-carbon electricity supplies.

Fission energy research in the Nuclear Science and Engineering department is focused on developing advanced nuclear reactor designs that include passive safety features, developing innovative proliferation-resistant fuel cycles, extending the life of nuclear fuels and structures, and reducing the capital and operating costs of nuclear power stations. These research goals are pursued via targeted technology options, based on advanced modeling and simulation techniques. The overall objective is to make nuclear power the most economical, safe, and environmentally benign way of generating electricity, thereby contributing to energy security and a sustainable global climate.

**Plasma Physics and Fusion Technology.** A different source of nuclear energy results from the controlled fusion of light elements, notably hydrogen isotopes. Since the basic source of fuel for fusion can be easily and inexpensively extracted from the ocean or from very abundant lithium, the supply is virtually inexhaustible. Fusion reactions can only readily occur in a fully ionized plasma heated to super high temperatures (150 million K). Such hot plasmas cannot be contained by material walls and are usually confined instead by strong magnetic fields. Recent progress within the international fusion community increases the likelihood that controlled fusion will become a practical source of energy within the next half-century.

Attainment of a fusion power plant involves the solution of many intellectually challenging physics and engineering problems. Included among these challenges are a mastery of the sophisticated field of plasma physics; the discovery of improved magnetic geometries to enhance plasma confinement; the development of materials capable of withstanding high stresses and exposure to intense radiation; and the need for great engineering ingenuity in integrating fusion power components into a practical, safe, and economical system. The department has strong programs in plasma fundamentals, materials for intense radiation fields, and engineering of fusion systems.

The fundamentals of plasmas also underlie novel methods for treatment of toxic gases, magnetohydrodynamic energy conversion, and ion propulsion, all topics of interest in the department. Students concentrating on applied plasma physics are trained not only to contribute to the advancement of controlled fusion but also to apply their knowledge in current industrial applications. In these plasma programs, the Department of Nuclear Science and Engineering is a leader in MIT’s broad, interdepartmental program of research and instruction in plasma physics and its varied applications.

**Nuclear and Radiation Science and Technology.** The department’s activities in nuclear and radiation science and technology are concerned with the continued development of low-energy nuclear science and its application to fields such as security, medicine and biology, information processing, materials research, industrial processes, and radiation detection.

Bionuclear science and engineering utilizes nuclear processes in a variety of ways that impact medicine and biology. For example, nuclear radiation can be used as a medical diagnostic tool through a variety of imaging techniques and therapies. Understanding the biological impact of radiation is also key to environmental and occupational health.

An exciting new frontier in nuclear science and engineering is to precisely control the quantum mechanical wave function of atomic and subatomic systems. Thus far, this has been achieved only in low-energy processes, particularly nuclear magnetic resonance, a form of nuclear spectroscopy which has allowed the basic techniques needed for quantum control.
to be explored in unprecedented detail. The department has initiated an ambitious program in this area, which promises to be widely applicable in nanotechnology. The ultimate achievement would be the construction of a “quantum computer,” which would be capable of solving problems that are far beyond the capacities of classical computers. Other significant applications are quantum-enabled sensors and actuators, secure communication, and the direct simulation of quantum physics.

Another important application area concerns the security aspects of nuclear science and technology. The future of nuclear energy is predicated, in significant part, on effective control of access to nuclear materials, facilities, and know-how. Research in the department includes the development of advanced technologies for detection of special nuclear materials and other sensitive materials, and the application of risk assessment methodologies to nuclear security problems. Nuclear technologies have been used to eliminate E. coli bacteria from food and anthrax from the mail system, and nuclear techniques are also being used and developed for the rapid, non-intrusive inspection of aircraft baggage and cargo.

**Extreme Materials.** An important area of research in the department which cuts across many of the primary applications of nuclear science and technology involves the study of materials in extreme environments. To achieve the full potential of nuclear energy from both fission and fusion reactors, it is necessary to develop special materials capable of withstanding intense radiation for long periods of time as well as high temperatures and mechanical stresses. It is also crucial to understand the phenomenon of corrosion in radiation environments. To develop a fundamental understanding of these phenomena, chemical and physical processes must be followed at multiple scales, from the atomic to the macroscopic, over timescales from less than a nanosecond to many decades, and even, in the case of nuclear waste, thousands of years. Materials research in the department draws on a wide array of new scientific tools, including advanced compact radiation sources, material probes and actuators, secure communication, and the direct simulation of quantum physics.

**COURSE 22 NUCLEAR SCIENCE AND ENGINEERING**

**Bachelor of Science in Nuclear Science and Engineering/Course 22**

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<tr>
<th>General Institute Requirements (GIRs)</th>
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<tr>
<td>Science Requirement</td>
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<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
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<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement [can be satisfied from among 8.03; 18.03 or 18.034; 22.01; 22.02; and 22.071J, in the Departmental Program]</td>
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<tr>
<td>Laboratory Requirement [can be satisfied by 22.09 in the Departmental Program]</td>
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<td>Total GIR Subjects Required for SB Degree</td>
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<td><strong>Communication Requirement</strong></td>
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<td>The program includes a Communication Requirement of 4 subjects:</td>
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<td>2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and 2 subjects designated as Communication Intensive in the major (CI-M).</td>
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<tr>
<td><strong>PLUS Departmental Program</strong></td>
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<tr>
<td>Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics)</td>
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<tr>
<td><strong>Basic Requirements</strong></td>
</tr>
<tr>
<td>2.005 Thermal-Fluids Engineering I, 12, REST; Physics II (GIR), Calculus II (GIR), 18.03</td>
</tr>
<tr>
<td>6.00 Introduction to Computer Science and Programming, 12, REST or 12.010 Computational Methods of Scientific Programming, 12; Calculus II (GIR), Physics I (GIR)</td>
</tr>
<tr>
<td>8.03 Physics II, 12, REST; Physics II (GIR), Calculus II (GIR)</td>
</tr>
<tr>
<td>18.03 Differential Equations, 12, REST; Calculus II (GIR) or 18.034 Differential Equations, 12, REST; Calculus II (GIR)</td>
</tr>
<tr>
<td>18.06 Linear Algebra, 12, REST; Calculus II (GIR)</td>
</tr>
<tr>
<td>22.01 Introduction to Nuclear Engineering and Ionizing Radiation, 12, REST 22.071J Electronics, Signals, and Measurement, 12, REST; 18.03</td>
</tr>
<tr>
<td><strong>Required Nuclear Science and Engineering Core Subjects</strong></td>
</tr>
<tr>
<td>22.02 Introduction to Applied Nuclear Physics, 12, REST; Physics II (GIR), Calculus II (GIR), 8.03*</td>
</tr>
<tr>
<td>22.033 Nuclear Systems Design Project, 12</td>
</tr>
<tr>
<td>22.05 Neutron Science and Reactor Physics, 12; 18.03, 22.02</td>
</tr>
<tr>
<td>22.09 Principles of Nuclear Radiation Measurement and Protection, 12, LAB, CI-M; 22.02</td>
</tr>
<tr>
<td>Choose two of the following:</td>
</tr>
<tr>
<td>22.058 Radiation Systems Engineering and Tomographic Imaging, 12; Physics II (GIR), 18.03</td>
</tr>
<tr>
<td>22.055 Radiation Biophysics, 12; permission of Instructor</td>
</tr>
<tr>
<td>22.06 Engineering of Nuclear Systems, 12; 2.005 Materials for Nuclear Applications, 12; permission of instructor</td>
</tr>
<tr>
<td><strong>Required Undergraduate Nuclear Science and Engineering Thesis</strong></td>
</tr>
<tr>
<td>22.ThT Undergraduate Thesis Tutorial (minimum of 3 units); 22.09</td>
</tr>
<tr>
<td>22.ThU Undergraduate Thesis (minimum of 9 units), CI-M; 22.ThT</td>
</tr>
<tr>
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<tr>
<td><strong>Departmental Program Units That Also Satisfy the GIRs</strong></td>
</tr>
<tr>
<td>Unrestricted Electives</td>
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<td></td>
</tr>
<tr>
<td><strong>Total Units Beyond the GIRs Required for SB Degree</strong></td>
</tr>
<tr>
<td>No subject can be counted both as part of the 17-subject GIRs and as part of the 192 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.</td>
</tr>
<tr>
<td><strong>Notes</strong></td>
</tr>
<tr>
<td>*Alternate prerequisites and corequisites are listed in the subject description.</td>
</tr>
<tr>
<td>For an explanation of credit units, or hours, please refer to the online help in the MIT Subject Listing &amp; Schedule, <a href="http://student.mit.edu/catalog/index.cgi">http://student.mit.edu/catalog/index.cgi</a>.</td>
</tr>
</tbody>
</table>
Interdisciplinary Research. Students and faculty in the department work closely with colleagues in several other departments, including Physics, Materials Science and Engineering, Mechanical Engineering, Electrical Engineering and Computer Science, and Political Science, and with the Sloan School of Management. The department is an active participant in the MIT Energy Initiative and in MIT’s interdisciplinary programs of instruction and research in the management of complex technological systems and technology and public policy.

UNDERGRADUATE STUDY

Bachelor of Science in Nuclear Science and Engineering/Course 22

The department’s undergraduate program offers a strong foundation in science-based engineering, providing the skills and knowledge for a broad range of careers. The program develops scientific and engineering fundamentals in the production, interactions, measurement, and control of radiation arising from nuclear processes. In addition, the program introduces students to thermal-fluid engineering, electronics, and computer methods. Building upon these fundamentals, students understand the principles, design, and appropriate application of nuclear-based systems that have broad societal impacts in energy, human health, and security—for example, reactors, imaging systems, detectors, and plasma confinement. In addition, they develop professional skills in quantitative research, written and oral technical communication, team building, and leadership. The program is excellent preparation for subsequent graduate education and research in a broad range of fields. In the nuclear field, there is high demand for nuclear engineers around the world as the nuclear energy industry continues to expand. Other nuclear and radiation applications are increasingly important in medicine, industry, and government.

A characteristic of the curriculum is the development of practical skills through hands-on education. This is accomplished through a laboratory subject on radiation physics, measurement, and protection (22.09), and through the laboratory components and exercises of the electronics (22.0711), imaging (22.058), and computational subjects. The concept of hands-on learning is continued with a 12-unit design subject focusing on nuclear systems and a 12-unit undergraduate thesis that is normally organized between the student and a faculty member of the department. Thesis subjects can touch on any area of nuclear science and engineering, including nuclear energy applications (fission and fusion) and nuclear science and technology (medical, physical, chemical, security, and material applications).

The department offers one undergraduate program leading to a Bachelor of Science in Nuclear Science and Engineering, Course 22, which is normally completed in four years. The Bachelor of Science program prepares students for a broad range of careers, from practical engineering work in the nuclear and other energy industries to graduate study in a wide range of technical fields, as well as entrepreneurship, law, medicine, and business.

The Course 22 degree program is accredited by the Accreditation Board for Engineering and Technology.

Additional information may be obtained from the student’s departmental advisor or from the department’s Academic Office (Room 24-102).

Minor in Nuclear Science and Engineering

The Minor in Nuclear Science and Engineering is open to all students who do not major in Course 22. The requirements for the minor are as follows:

Students must complete a total of six subjects, which typically include 8.03 and 18.03 as prerequisites to departmental subjects, plus:

- 22.01 Introduction to Nuclear Engineering and Ionizing Radiation
- 22.02 Introduction to Applied Nuclear Physics
- and two of the following:
  - 22.05 Neutron Science and Reactor Physics
  - 22.06 Engineering of Nuclear Systems
  - 22.058 Radiation Systems Engineering and Tomographic Imaging
  - 22.09 Principles of Nuclear Radiation Measurement and Protection

The department’s minor advisor will ensure that each minor program forms a coherent group of subjects.

Combined Bachelor’s and Master’s Programs

The five-year programs leading to a joint Bachelor of Science in Chemical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering, Nuclear Science and Engineering, or Physics and a Master of Science in Nuclear Science and Engineering are designed for students who decide relatively early in their undergraduate career that they wish to pursue a graduate degree in nuclear engineering. Students must submit their application for this program during the second term of their junior year and be judged to satisfy the graduate admission requirements of the department. The normal expectations of MIT undergraduates for admission to the five-year program are an overall MIT grade point average of at least 4.3, and a strong mathematics, science, and engineering background with GPA of at least 4.0.

The nuclear science and engineering thesis requirements of the two degrees may be satisfied either by completing both an SB thesis and an SM thesis, or by completing an SM thesis and any 12 units of undergraduate credit.

For further information, interested students should contact either their undergraduate department or the Department of Nuclear Science and Engineering.

Inquiries

Further information on undergraduate programs, admissions, and financial aid may be obtained from the department’s Academic Office, Room 24-102, 617-258-5682.

GRADUATE STUDY

The nuclear science and engineering field is broad and many undergraduate disciplines provide suitable preparation for graduate study.

An undergraduate degree in physics, engineering physics, chemistry, mathematics, materials science, or chemical, civil, electrical, mechanical, or nuclear science and engineering can provide a good foundation for graduate study.
take the Graduate Record Examination (GRE).

Activity or a design project.

It may have been achieved through an independent undergraduate research.

A subject covering the mechanics of materials is recommended, particularly for students wishing to specialize in fission.

Electronics and measurement, and computation.

Thermodynamics, fluid mechanics, heat transfer, mathematics, including the study and application of ordinary differential equations. It is also highly recommended that students will have studied partial differential equations and linear algebra.

Chemistry—At least one term of general, inorganic, and physical chemistry.

Engineering fundamentals—The graduate curriculum builds on a variety of engineering fundamentals, and incoming students are expected to have had an introduction to thermodynamics, fluid mechanics, heat transfer, electronics and measurement, and computation. A subject covering the mechanics of materials is recommended, particularly for students wishing to specialize in fission.

Laboratory experience—This component is essential. It may have been achieved through an organized subject, and ideally was supplemented with an independent undergraduate research activity or a design project.

Applicants for admissions are required to take the Graduate Record Examination (GRE).

Master of Science in Nuclear Science and Engineering

The object of the master of science program is to give the student a good general knowledge of nuclear science and engineering and to provide a foundation either for productive work in the nuclear field or for more advanced graduate study. The general requirements for the SM degree are listed under Graduate Education in Part 1. Subject 22.101 Applied Nuclear Physics or its equivalent is required for all master of science degree candidates.

Other subjects may be selected in accordance with the student’s particular field of interest. Master of science candidates may specialize in one of several fields: including nuclear fission technology, applied plasma physics, nuclear materials, and nuclear science and technology. Detailed descriptions of the subjects available in each of these areas may be found in the Course 22 listings in the online MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi. Some students pursue a master of science degree in technology and policy in parallel with the Course 22 master of science program.

Students with adequate undergraduate preparation normally need 18 months to two years to complete the requirements for the master of science. Additional information concerning the requirements for the Master of Science in Nuclear Science and Engineering, including lists of recommended subjects, may be obtained from the department’s Academic Office, Room 24-102.

Master of Science in Technology and Policy

The Master of Science in Technology and Policy is an engineering research degree with a strong focus on the role of technology in policy analysis and formulation. The Technology and Policy Program (TPP) curriculum provides a solid grounding in technology and policy by combining advanced subjects in the student’s chosen technical field with courses in economics, politics, and law. Many students combine TPP’s curriculum with complementary subjects to obtain dual degrees in TPP and either a specialized branch of engineering or an applied social science such as political science or urban studies and planning. For additional information, see the program description under Engineering Systems Division or visit http://web.mit.edu/tpp/.

Nuclear Engineer

The program of study leading to the nuclear engineer’s degree provides deeper knowledge of nuclear science and engineering than is possible in the master’s program and is intended to train students for creative professional careers in engineering application or design.

The general requirements for this degree, as described under Graduate Education in Part 1, include 162 units of subject credit plus a thesis. Each student must plan an individually selected program of study, approved in advance by the faculty advisor, and must complete, and orally defend, a substantial project of significant value.

The objectives of the program are to provide the candidate with 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’s degree is generally the subject of an engineer’s thesis. A student with full undergraduate preparation normally needs two years to complete the program. Additional information may be obtained from the department.

Doctor of Philosophy and Doctor of Science

The program of study leading to either the doctor of philosophy or the doctor of science degree aims to give comprehensive knowledge of nuclear science and engineering, to develop competence in advanced engineering research, and to develop a sense of perspective in assessing the role of nuclear science and technology in our society.

General requirements for the doctorate are described under Graduate Education in Part 1 and in the Graduate School Policy and Procedures Manual. The specific requirements of the Department of Nuclear Science and Engineering are the math and physics competency requirement, the engineering requirement, the general examination, the core/major/minor program requirement, and the doctoral thesis.

Upon satisfactory completion of the requirements, the student ordinarily receives a PhD unless he or she requests an ScD. The requirements for both degrees are the same.

Students admitted for the master of science or nuclear engineer’s degree must apply to the Department of Nuclear Science and Engineering’s Admissions Committee for admission to the doctoral program.

Students admitted for a doctoral degree must complete the math and physics competency requirement and the engineering requirement prior to taking the general examination. Before starting doctoral research, each student is required to pass a general examination whose purpose is to establish intellectual potential as well as breadth and depth of knowledge. The general exam has two sections: a written component and an oral component. Both components
must be passed in order to register for doctoral thesis credit. Candidates for a doctoral degree must also satisfactorily complete (with an average grade of B or better) an approved program of advanced studies—the core/major/minor requirement. The program requires that students take not less than 84 credit hours of subjects (excluding special problems), of which two subjects (24 units) must be selected from the following subjects (the core): 22.101, 22.105, and 22.106. Three subjects (36 units) comprise a field of specialization (the major) that will be closely related to the student’s doctoral thesis topic. Two subjects (24 units) must be coordinated subjects clearly outside the field of specialization (the minor). None of the 36 units selected by the student in the field of specialization (the major) may be from the list of subjects specified for general examination questions chosen by the student.

Doctoral research may be undertaken either in the Department of Nuclear Science and Engineering or in a nuclear-related field in another department. Appropriate areas of research are described generally in the introduction to the department, and a detailed list may be obtained from the Department of Nuclear Science and Engineering.

Research Facilities
The department’s programs are supported by a number of outstanding experimental facilities for advanced research in nuclear science and engineering.

The MIT Research Reactor in the Nuclear Reactor Laboratory operates at a power of 6 MW and is fueled with U-235 in a compact light-water cooled core surrounded by a heavy-water reflector. This reactor provides a wide range of radiation-related research and teaching opportunities for the students and faculty of the department. Major programs to study corrosion in a nuclear environment are currently in place. Details of the laboratory’s research programs and facilities are given in the section on Interdisciplinary Research and Study.

The department utilizes extensive experimental plasma facilities for the production and confinement of large volumes of highly ionized plasmas and for studies of plasma turbulence, particle motions, and other phenomena.

Most of the departmental research on plasmas and controlled fusion is carried out in the Plasma Science and Fusion Center. The department has played a major role in the design and development of high magnetic-field fusion devices. Currently there are three major plasma experiments at MIT—the Alcator C-Mod Tokamak, the Levitated Dipole Experiment, and the Versatile Toroidal Facility—all located in the Plasma Science and Fusion Center (described in the section on Interdisciplinary Research and Study in Part 1). Through its activities in the Plasma Science and Fusion Center, the department is also the national leader in the design of magnets, both copper and superconducting.

The thermal hydraulics and nanofluids laboratory is equipped with state-of-the-art instrumentation for measurement of fluid thermo-physical properties, and flow loops for characterizing convective heat transfer and fluid dynamics behavior. A particularly novel facility uses infrared thermography to study fundamental phenomena of boiling, such as bubble nucleation, growth, and departure from a heated surface.

Research in the laboratory for electrochemical interfaces centers on understanding the response of surface structure and physical chemistry when driven by dynamic environments of chemical reactivity and mechanical stress. The H. H. Uhlig Corrosion Laboratory investigates the causes of failure in materials, with an emphasis on nuclear materials. In the quantum engineering laboratory, the focus is on the engineering of quantum spin-based sensors, actuators, and computers.

In addition to the above facilities, the department has a nuclear instrumentation laboratory and a 14 MeV neutron source. Laboratory space and shop facilities are available for research in all areas of Nuclear Science and Engineering. A state-of-the-art scanning electron microscope that can be used to study irradiated specimens is available. A number of computer workstations dedicated to simulation, modeling, and visualization, as well as MIT’s extensive computer facilities, are used in research and graduate instruction.

Financial Aid
Financial aid for graduate students is available in the form of research and teaching assistantships, department-administered fellowships, and supplemental subsidies from the College Work-Study Program. Assistantships are awarded to students with high quality academic records. The duty of a teaching assistant is to assist a faculty member in the preparation of subject materials and the conduct of classes, while that of a research assistant is to work on a research project under the supervision of one or more faculty members.

Most fellowships are awarded in April for the following academic year. Assistantships are awarded on a semester basis. The assignment of teaching assistants is made before the start of each semester, while research assistants can be assigned at any time. Essentially all students admitted to the doctoral program receive financial aid for the duration of their education.

Application for financial aid should be made to Professor Jacopo Buongiorno, Room 24-206, 617-253-7316.

Inquiries
Additional information on graduate admissions and academic and research programs may be obtained from the department’s Academic Office, Room 24-102, 617-253-3814, cegan@mit.edu.

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and Fusion Center and Nuclear Science and
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Richard C. Lanza, PhD
Senior Research Scientist

Principal Research Engineer
John A. Bernard, Jr., PhD
Principal Research Engineer, Nuclear Reactor
Laboratory and Nuclear Science and Engineering

Principal Research Scientist
Charles Forsberg, PhD

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Alan Hanson, PhD
Akihiro Kushima, PhD
Thomas McKrell, PhD
Michael Short, PhD

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Peter Stahle, BSME

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Xili Duan, PhD
Joseph Fricano, PhD
Jon Won Kim, PhD
Won Young Lee, PhD
Jun Jie Niu, PhD
Liang Qi, PhD
Xiofeng Qian, PhD

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Piero Baglioni, PhD
Adam Bernstein, PhD
Brandon Blackburn, PhD
John Dobbs, PhD
Georges El Fakhri, PhD
Anna Erickson, PhD
Henry Foxhill, PhD
Anthony Galatsis, PhD
Jonathan Gibbs, PhD
Pavel Hejzlar, ScD
Jonathan Hodges, PhD
Michael Hynes, PhD
John Jackson, PhD
Andrew Kadak, PhD
Genrich Krasko, PhD
Djamel Lakehal, PhD
Hua Li, PhD
Luz Leal, PhD
Xi Lin, PhD
Yu-Chieh Lo, PhD
Francesco Mallamace, PhD
Shigenobu Ogata, PhD
David Perticone, PhD
Pradip Saha, PhD
Shuanghe Shi, PhD
Piero Tartaglia, PhD
Grum Tekiemariam, PhD
Sebastian Teysserey, PhD
Siju Thomas, PhD
Dwight Williams, PhD
Zhiwen Xu, PhD
Vitaliy Ziskin

Professors Emeriti
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Professor of Nuclear Science and Engineering
Systems, Emeritus
Sow-Hsin Chen, PhD
Professor of Nuclear Science and Engineering,
Emeritus
Michael John Driscoll, ScD
Professor of Nuclear Science and Engineering,
Emeritus
Thomas Henderson Dupree, PhD
Professor of Nuclear Science and Engineering
and Physics, Emeritus
Jeffrey P. Freidberg, PhD  
Professor of Nuclear Science and Engineering, Emeritus

Elias Panayiotis Gyftopoulos, ScD  
Professor of Nuclear Science and Engineering and Mechanical Engineering, Emeritus

Kent Forrest Hansen, ScD  
Professor of Nuclear Science and Engineering, Emeritus

Otto Karl Harling, PhD  
Professor of Nuclear Science and Engineering, Emeritus

David Dayton Lanning, PhD  
Professor of Nuclear Science and Engineering, Emeritus

Ronald Michael Latanision, PhD  
Professor of Materials Science and Nuclear Science and Engineering, Emeritus

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Associate Professor of Nuclear Science and Engineering, Emeritus

Ronald Richard Parker, PhD  
Professor of Electrical Engineering and Nuclear Science and Engineering, Emeritus

Kenneth Calvin Russell, PhD  
Professor of Metallurgy and Nuclear Science and Engineering, Emeritus

Neil Emmanuel Todreas, ScD  
Professor of Nuclear Science and Engineering and Mechanical Engineering, Emeritus

Sidney Yip, PhD  
Professor of Nuclear Science and Engineering and Materials Science and Engineering, Emeritus
The School of Humanities, Arts, and Social Sciences offers students the chance to explore creative expressions of the human imagination, understand the human past, and examine social, economic, and political change over time and the cultural and institutional contexts in which science and technology are rooted.
The great strength of MIT lies not only in the fact that it fosters creativity and innovation in science and technology, but that it also pioneers in exploring the social and cultural environments in which science and technology are produced.

A chief concern of the School’s undergraduate program has long been the provision of subjects to fulfill the Institute’s Humanities, Arts, and Social Sciences Requirement. The object of the requirement, broadly stated, is to ensure that every undergraduate at MIT is exposed to a wide range of interpretive and analytic approaches in the humanities, arts, and social sciences.

The School’s five doctoral programs (Economics; History, Anthropology, and Science, Technology and Society [HASTS]; Linguistics; Philosophy; and Political Science) are among the leading graduate programs of their kind in the world. They prepare students primarily for teaching and research, and performance. Through their publications, lectures, and seminars, the faculty strive to expand the frontiers of human knowledge and awareness. Interdisciplinary collaboration is a hallmark of this activity.


Minor programs have been established in all of the School’s sections, programs, and departments, as well as in African and African Diaspora Studies, Ancient and Medieval Studies, Applied International Studies, Asian and Asian Diaspora Studies, Chinese, Comparative Media Studies, International Development, Latin American and Latino Studies, Middle Eastern Studies, Psychology, Public Policy, Russian and Eurasian Studies, and Women’s and Gender Studies. These minors offer another opportunity for focused undergraduate exploration in the humanities, arts, and social sciences. For further details, see the section on interdisciplinary undergraduate minors in Part 3.

In response to the increasing demand on US campuses for internationalization of the curriculum, the Foreign Languages and Literatures Section has created new language and culture programs in Japanese and Chinese. The Japanese Language and Cultural Program has built the most technologically advanced Japanese language and culture education curriculum in the world, using online computer networks and interactive videos. The MIT International Science and Technology Initiatives, located at the Center for International Studies, support student internships in China, France, Germany, India, Israel, Italy, Japan, Mexico, Singapore, and Spain.

The School’s newest graduate degree program is an SM in Science Writing, which focuses on the ability to interpret and explain science to the wider public. The School also offers an SM degree and an SB degree in Comparative Media Studies; both degree programs focus on new and historical media and their global impact on society, economy, and politics.

History

MIT’s Course 21 (Humanities) was considered innovative when it was established in the 1950s, although its roots go back to the opening of the Institute in 1865. The 1865 course bulletin offered a curriculum option called the Course of Science and Literature, which encompassed the study of humanities and social science subjects. The science and literature option developed into Course 9, and by 1882 was renamed General Studies, offering “a larger amount of history, economics, language, and literature than is possible in technical courses.”

After the Second World War, MIT’s evaluation of general and humanistic education changed dramatically. The Institute saw the need to emphasize the “humanistic-social stem” of the engineering curriculum. During the postwar period, the School of Humanities and Social Studies (later the School of Humanities and Social Science) was established, allowing students to pursue a degree that combined engineering or science with humanities in a 60/40 ratio over four years. By this time, the Department of Economics and Social Science had been established within the School, attracting some of the nation’s best graduate students and achieving recognition as a leading department.

During the 1960s the School grew rapidly, was reorganized into most of its current departments and sections, and began to grant full-scale degrees. In 1965, Political Science became a separate department, offering both undergraduate and graduate degrees. Philosophy, History, Literature, and Music all emerged as separate sections. In 1966, for the first time ever, MIT students could major in the humanities.

In the 1970s the School continued to define separate programs: the Anthropology and Archaeology Program (now Anthropology Program), established in 1971, and the Writing Program (now Program in Writing and Humanistic Studies), established in 1974. A rearrangement of sections in 1976 produced the Foreign Languages and Literatures Section and the Department of Linguistics and Philosophy. The interdisciplinary Program in Science, Technology, and Society began in 1977, and in 1988 a doctoral program in the History and Social Study of Science and Technology (later called the History, Anthropology, and Science, Technology, and Society program) was established in collaboration with the faculties of History and Anthropology. In 1990, the School replaced the generic SB degree in Humanities with SB degrees in specified areas of humanistic study: Anthropology, History, Literature, Foreign Languages and Literatures, Music, and Writing. In 1999, it introduced an SM degree in Comparative Media Studies and in 2002, an SM degree in Science Writing. In 2003, an SB degree in Comparative Media Studies was introduced. To reflect the growth and incorporation of the arts at MIT and in celebration of its 50th anniversary in 2000, the School changed its name to the School of Humanities, Arts, and Social Sciences.

Interdepartmental Programs

The interdepartmental centers, groups, and programs that reside in the School of Humanities, Arts, and Social Sciences include the following:

- Abdul Latif Jameel Poverty Action Laboratory
- Center for International Studies
- Women’s and Gender Studies Program
- Knight Science Journalism Fellows Program

See Interdisciplinary Research and Study in Part 3 for further information.
### Degrees Offered in the School of Humanities, Arts, and Social Sciences

<table>
<thead>
<tr>
<th>Program</th>
<th>Course Code</th>
<th>Major/Field</th>
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<tbody>
<tr>
<td>Anthropology</td>
<td>21A</td>
<td>Anthropology</td>
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<tr>
<td>Comparative Media Studies</td>
<td>CMS</td>
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<tr>
<td>Economics</td>
<td>14</td>
<td>Economics</td>
</tr>
<tr>
<td>Foreign Languages and Literatures</td>
<td>21F</td>
<td>Foreign Languages and Literatures</td>
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<tr>
<td>History</td>
<td>21H</td>
<td>History</td>
</tr>
<tr>
<td>Humanities</td>
<td>21*</td>
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<td>Humanities and Engineering</td>
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<tr>
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<tr>
<td>Linguistics and Philosophy</td>
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<td>Literature</td>
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<tr>
<td>Music and Theater Arts</td>
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<tr>
<td>Political Science</td>
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<tr>
<td>Program in Science, Technology, and Society</td>
<td>STS</td>
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<tr>
<td>Writing and Humanistic Studies</td>
<td>21W</td>
<td>Writing</td>
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<tr>
<td>Science Writing</td>
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<td>Science Writing</td>
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</tbody>
</table>

### Notes
* Students majoring in German or doing a “major departure” (an independently designed major in one of several specified fields) receive the generic SB degree in Humanities.

Many departments make it possible for a graduate student to pursue a simultaneous master's degree.
Anthropology studies humankind from a comparative perspective that emphasizes the diversity of human behavior and the importance of culture in explaining that diversity. While the discipline encompasses the biological nature of our species and the material aspects of human adaptation, it takes as fundamental the idea that we respond to nature and natural forces in large part through culture. Anthropology, then, is the study of human beings as cultural animals. Sociocultural anthropology, the focus of the MIT program, draws its data from the direct study of contemporary peoples living in a wide variety of circumstances, from peasant villagers and tropical forest hunters and gatherers to urban populations in modern societies, professionals in technological organizations, as well as from the history and prehistory of these peoples.

Anthropology at MIT offers students a broad exposure to scholarship on human cultures, providing perspectives relevant to other fields in the humanities, social sciences, sciences, and engineering. It also provides more intensive introduction to areas of faculty specializations: social and political organization, science and technology, environmentalism, agriculture and food production, religion and symbolism, photography and film, ethics, law and human rights, gender studies, nationalism and ethnic identity, and the particular cultures of medicine and scientific research.

Excluding Independent Study, Thesis, and Special Subjects, the anthropology curriculum is divided into seven topic clusters that provide depth on related topics:

- **21A.00 and 21A.01** are core subjects.
- **21A.100 to 21A.199** address general issues related to culture and identity.
- **21A.200 to 21A.299** concern religion, belief, myth, and magic in different cultures.
- **21A.300 to 21A.399** examine health, disease, medicine, and biology in global and local settings.
- **21A.400 to 21A.499** investigate issues and conflicts related to the environment, law, and human rights.
- **21A.500 to 21A.599** focus on science, technology, and media in various institutional, economic, and political contexts.
- **21A.800 to 21A.899** are methods and theory subjects.

For additional information, see [http://web.mit.edu/anthropology/course_desc/index.html](http://web.mit.edu/anthropology/course_desc/index.html).

Students taking a concentration in anthropology should enroll in either 21A.00 Introduction to Anthropology: Comparing Human Cultures or 21A.01 How Culture Works, and two other subjects. Anthropology subjects qualify for several interdisciplinary concentrations, including those in Women’s and Gender Studies, Latin American and Latino Studies, and Science, Technology, and Society.

**Bachelor of Science in Anthropology/ Course 21A**

The undergraduate program leading to the degree of Bachelor of Science in Anthropology (Course 21A) provides a thorough grounding in cultural anthropology.

Majors learn about the concept of culture and the processes by which humans make meaningful transactions, the nature of ethnographic fieldwork, and the connections between anthropology and the other social sciences. Majors study the theories explaining human behavior as well as the range of methods anthropologists use to analyze empirical data. Students can focus on geographical areas, such as Latin America or modern western society, and on issues like neocolonialism, ethnic conflict, human rights, environmental movements, globalization, or expressive, medical, or scientific cultures.

The anthropology student comes to understand that the hallmark of the discipline is the comparative study of human societies. Emphasis is on understanding diversity and the importance of the concept of culture in explaining that diversity, as well as on learning about the universals of behavior that may underlie diversity.

**Minor in Anthropology**

The Minor in Anthropology consists of six subjects arranged into three tiers as shown below. Students create individual programs with the help of the minor advisor to ensure that they gain a coherent introduction to the methods, approaches, and some of the results of the discipline.

**Tier I**

**One subject:**

- 21A.00 Introduction to Anthropology: Comparing Human Cultures
- 21A.01 How Culture Works

**Tier II**

Four subjects with a unifying theme (not to include 21A.00 or 21A.01). See the list of suggested themes above; students may also suggest alternative unifying themes.

**Tier III**

**One subject:**

- 21A.852 Seminar in Anthropological Theory
- 21A.802 Seminar in Ethnography and Fieldwork

**Joint Degree Programs**

Joint degree programs are offered in anthropology in combination with a field in engineering or science (21E, 21S). See the joint degree programs listed under Humanities. Either 21A.00 or 21A.01 is strongly recommended as a preliminary subject for all anthropology degree programs.

**HASTS Graduate Program**

The Anthropology Program, the History faculty, and the Program in Science, Technology, and Society collaborate in the graduate program History, Anthropology, and Science, Technology and Society (HASTS) leading to a PhD; see the description under the Program in Science, Technology, and Society, [http://web.mit.edu/catalog/degree.human.scienc.html](http://web.mit.edu/catalog/degree.human.scienc.html).

Subjects in anthropology are described in the online MIT Subject Listing & Schedule, [http://student.mit.edu/catalog/m21Aa.html](http://student.mit.edu/catalog/m21Aa.html). Further information on subjects and programs may be obtained from the Anthropology Office, Room E53-335, 617-253-3065.

**Faculty and Staff**

**Faculty and Teaching Staff**

Susan S. Silbey, PhD
Professor of Sociology and Anthropology
Professor of Behavioral and Policy Sciences, Sloan School of Management
Leon and Anne Goldberg Professor of Humanities
Section Head
Bachelor of Science in Anthropology/Course 21A

General Institute Requirements (GIRs)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Total GIR Subjects Required for SB Degree</td>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>

Communication Requirement
The program includes a Communication Requirement of 4 subjects:
- 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H);
- 2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

<table>
<thead>
<tr>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>21A.00 Introduction to Anthropology: Comparing Human Cultures, 12, HASS-S†</td>
<td></td>
</tr>
<tr>
<td>21A.01 How Culture Works, 12, HASS-S†</td>
<td>48</td>
</tr>
<tr>
<td>21A.802 Seminar in Ethnography and Fieldwork, 12, HASS-S, CI-M *</td>
<td>48</td>
</tr>
<tr>
<td>21A.852 Seminar in Anthropological Theory, 12, HASS-S, CI-M *</td>
<td>48</td>
</tr>
</tbody>
</table>

Restricted Electives
A coherent program of eight anthropology subjects which may include a pre-thesis tutorial and a thesis. The decision to write a thesis is made in consultation between the student and advisor.

Departmental Program Units That Also Satisfy the GIRs

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
</tr>
</tbody>
</table>

Unrestricted Electives

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>72–78</td>
</tr>
</tbody>
</table>

Total Units Beyond the GIRs Required for SB Degree

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>180</td>
</tr>
</tbody>
</table>

Notes
*Prerequisites and corequisites are listed in the subject description.
† Students who entered prior to fall 2010 may use this subject to satisfy the HASS-D requirement.

For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.
Established in 1999–2000, the program in Comparative Media Studies integrates the study of contemporary media (film, television, digital systems) with a broad historical understanding of older forms of human expression. The program embraces theoretical and interpretive principles drawn from the central humanistic disciplines of literary study, history, anthropology, art history, and film studies, but aims as well for a comparative synthesis that is responsive to the distinctive emerging media culture of the 21st century. Students explore the complexity of the media environment by learning to think across media, to see beyond the boundaries imposed by older medium-specific approaches to the study of audio-visual and literary forms.

The comparative and cross-disciplinary nature of both the graduate and undergraduate programs is embodied in a faculty drawn from Art and Architecture; Anthropology; Foreign Languages and Literatures; History; Literature; Music and Theater Arts; Philosophy; Writing and Humanistic Studies; Science, Technology, and Society; Media Arts and Sciences; Political Science; and Urban Studies and Planning.

**UNIVERSITY STUDIES**

The undergraduate program—established in 1982 under its former name, Film and Media Studies—serves as preparation for advanced study in a range of scholarly and professional disciplines and also for careers in media or industry.

**Bachelor of Science in Comparative Media Studies/Course CMS**

The SB in Comparative Media Studies requires 10 subjects. Majors are required to take 21L.011, CMS.100, one mid-tier subject, one capstone subject, and six electives. A pre-thesis tutorial (CMS.ThT) and thesis (CMS.ThU) may be substituted for one elective.

**Minor in Comparative Media Studies**

The minor requires six subjects that reflect the comparative study of media, including 21L.011 or CMS.100, one mid-tier subject, one capstone subject, and three electives. Each student designs his or her own plan of study in consultation with a field advisor.

**HASS Concentration**

The HASS Concentration component consists of four subjects that reflect the comparative study of media. Each concentrator designs his or her own plan of study in consultation with a field advisor.

**Joint Degree Programs**

The joint degree programs (21E or 21S) require eight CMS subjects, plus six subjects in an engineering or science major. Students are required to take 21L.011 or CMS.100; one mid-tier subject; one capstone subject; and five CMS electives. A pre-thesis tutorial (CMS.ThT) and thesis (CMS.ThU) may be substituted for one CMS elective. Students must obtain approval for their course selection from an advisor in their engineering or science field, and must also file a petition with the Subcommittee on the Communication Requirement. See joint degree programs listed under the Department of Humanities section.

**GRADUATE STUDY**

The graduate program comprises a two-year course of study leading to a Master of Science in Comparative Media Studies. The program aims to prepare students for careers in fields such as journalism, teaching and research, government or public service, museum work, information science, corporate consulting, media industry marketing and management, and educational technology.

CMS graduate students usually take three 12-unit subjects per term, plus a 3-unit colloquium. All students take three introductory seminars (Media Theories and Methods I and II, and Major Media Texts) during their first year, as well as two terms of Workshop, a subject that offers hands-on experience in media. In their final term they take a 24-unit subject devoted to completing the master’s thesis, plus the 3-unit Colloquium in Comparative Media. Typically, students will graduate with a total of 144 units; however a minimum of 139 units is required for the master’s degree in order to accommodate some electives that are 9-unit instead of 12-unit subjects.

Students may enter the program with a degree from a wide range of undergraduate majors, including the liberal arts, the social sciences, journalism, computer science, and management.

**Graduate subjects include:**

**Required Subjects**

- CMS.790 Media Theories and Methods I
- CMS.791 Media Theories and Methods II
- CMS.796 Major Media Texts
- CMS.801 Media in Transition
- CMS.950 Workshop I
- CMS.951 Workshop II
- CMS.980 Master’s Thesis
- CMS.990 Colloquium in Comparative Media

**Electives**

- CMS.809 Transmedia Storytelling: Modern Science Fiction
- CMS.810 The Nature of Creativity
- CMS.811 Introduction to Philosophy of the Arts
- CMS.812 Topics in National and Post-National Cinema
- CMS.813 Silent Film
- CMS.814 Phantasmal Media: Theory and Practice
- CMS.815 Games for Social Change
- CMS.820 Philosophy of Film
- CMS.821 Fans and Fan Cultures
- CMS.827 Imagination, Computation, and Expression Studio
- CMS.828 Advanced Identity Representation
- CMS.830 Studies in Film
- CMS.831 Systems Visualization
- CMS.836 The Social Documentary: Analysis and Production
- CMS.837 Film, Music, and Social Change: Intersections of Media and Society
- CMS.838 Innovation in Documentary: Technologies and Techniques
- CMS.840 Literature and Film
- CMS.841 Introduction to Videogame Theory
- CMS.843 The Role of the Gamer: Theory, Criticism, and Practice
- CMS.845 Interactive and Non-linear Narrative: Theory and Practice
- CMS.846 The Word Made Digital
- CMS.860 Introduction to Civic Media
- CMS.861 Networked Social Movements: Media and Mobilization
- CMS.862 Civic Media Collaborative Design Studio
- CMS.863 Computer Games and Simulations for Investigation and Education
- CMS.864 Game Design
- CMS.866 Writing for Videogames
- CMS.867 Identity and the Internet
- CMS.868 Social and Cultural Facets of Digital Games
Bachelor of Science in Comparative Media Studies/Course CMS

General Institute Requirements (GIRs)  Subjects
Science Requirement 6
Humanities, Arts, and Social Sciences Requirement [four subjects may be satisfied by subjects in the Departmental Program] 8
Restricted Electives in Science and Technology (REST) Requirement 2
Laboratory Requirement 1
Total GIR Subjects Required for SB Degree 17

Communication Requirement
The program includes a Communication Requirement of 4 subjects:
2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and
2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program  Units
Required Subjects 48
Tier I
CMS.100 Introduction to Media Studies, 12, HASS-H†, CI-H

Tier II (Mid-tier)
Choose one of the following:
CMS.400 Media Systems and Texts, 12, HASS-H, CI-M; one subject in CMS or permission of instructor
CMS.403 Media and Methods: Performing, 12, HASS-H, CI-M; CMS.100, or permission of instructor
CMS.405 Media and Methods: Seeing and Expression, 12, HASS-H, CI-M; CMS.100
CMS.407 Media and Methods: Sound, 12, HASS-H, CI-M

Tier III (Capstone)
Choose one of the following:
21L.706 Studies in Film, 12, HASS-H, CI-M; CMS.100, or permission of instructor
21L.715 Media in Cultural Context, 12, HASS-H, CI-M; two subjects in CMS and/or Literature, or permission of instructor

Restricted Electives 72
Students choose six restricted electives. Qualified students may, with departmental approval, substitute a pre-thesis tutorial (CMS.ThT) and thesis (CMS.ThU) for one elective.

Departmental Program Units That Also Satisfy the GIRs (48)
Unrestricted Electives 60–108
Total Units Beyond the GIRs Required for SB Degree 180
No subject can be counted both as part of the 17-subject GIRs and as part of the 180 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

Notes
1 Students who entered prior to fall 2010 may use this subject to satisfy the HASS-D requirement.

Graduate subjects in comparative media studies are described in the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.

Inquiries
For more information on the undergraduate and graduate programs in Comparative Media Studies, contact the CMS Office, Room E15-331, 617-253-3599, fax 617-258-5133, cms@mit.edu.

Faculty and Teaching Staff

Professors
Junot Díaz, MFA
Professor of Writing
Peter Donaldson, PhD
Ford Foundation Professor in the Humanities
Mary Fuller, PhD
Professor of Literature
Elizabeth Garrels, PhD
Professor Spanish and Latin American Studies
Stefan G. Helmreich, PhD
Professor of Anthropology
Diana Henderson, PhD
Professor of Literature
MacVicar Faculty Fellow

CMS.871 Media in Cultural Context
CMS.876 History of Media and Technology
CMS.880 From Print to Digital: Technologies to the Word, 1450–Present
CMS.888 Advertising and Popular Culture: East Asian Perspectives
CMS.901 Behind the Headlines: Current Debates in Media
CMS.915 Understanding Television
CMS.920 Popular Culture and Narrative
CMS.922 Media Industries and Systems
CMS.925 Film Music
CMS.935 Documentary Photography and Photojournalism: Still Images of a World in Motion
CMS.992 Portfolio in Comparative Media
CMS.993 Teaching in Comparative Media
CMS.994–CMS.995 Independent Study

FACULTY AND STAFF

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Mary Fuller, PhD
Professor of Literature
Elizabeth Garrels, PhD
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Stefan G. Helmreich, PhD
Professor of Anthropology
Diana Henderson, PhD
Professor of Literature
MacVicar Faculty Fellow
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Professor of Literature

James Paradis, PhD  
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Director, Comparative Media Studies Program

Jeffrey S. Ravel, PhD  
Professor of History

Irving Singer, PhD  
Professor of Philosophy  
(On leave)

David Thorburn, PhD  
Professor of Literature  
MacVicar Faculty Fellow  
Director, MIT Communications Forum

William Uricchio, PhD  
Professor of Comparative Media Studies  
Director, Comparative Media Studies Program  
(On leave)

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S. C. Fang Professor of Chinese Language and Culture

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Associate Professor of History  
Acting Associate Dean, School of Humanities, Arts, and Social Sciences

Ian Condry, PhD  
Mitsui Career Development Associate Professor of Japanese Cultural Studies

Douglas A. (Fox) Harrell, Jr., PhD  
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Heather Hendershot, PhD  
Associate Professor of Comparative Media Studies

Eric Klopfer, PhD  
Associate Professor of Education  
Director, Scheller Teacher Education Program

Nick Montfort, PhD  
Associate Professor of Digital Media

Jay Scheib, MFA  
Associate Professor of Theater Arts

Natasha Dow Schüll, PhD  
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T. L. Taylor, PhD  
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(On leave, fall)

Christine J. Walley, PhD  
Associate Professor of Anthropology

Assistant Professors  
Vivek Bald, PhD  
Assistant Professor of Writing and Digital Media

Eugenie A. Brinkema, PhD  
Assistant Professor of Contemporary Literature and Media  
(On leave)

Sasha Costanza-Chock, PhD  
Assistant Professor of Comparative Media Studies

Graham M. Jones, PhD  
Assistant Professor of Anthropology

Bruno Perreau, PhD  
Assistant Professor of French Studies

Hanna Rose Shell, PhD  
Assistant Professor of Science, Technology, and Society

Senior Lecturers  
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Senior Lecturer in Writing

Ellen Crocker, MA  
Senior Lecturer in German

Wyn Kelley, PhD  
Senior Lecturer in Literature

Martin Marks, PhD  
Senior Lecturer in Music

Lecturers  
M. Flourish Klink, SM  
Lecturer in Comparative Media Studies

Andrea Walsh, PhD  
Lecturer in Writing and Humanistic Studies

Visiting Lecturer  
Christopher Weaver, CAS  
Visiting Lecturer in Comparative Media Studies

Research Staff

Research Managers  
Federico Casalegno, PhD  
Kurt Fendt, PhD  
Scot Osterweil, BA  
Philip Tan, MS

Postdoctoral Associates/Fellows  
Amaranth Borsuk, PhD  
Hye Jean Chung, PhD  
Clara Fernandez Vara, PhD  
Leopoldo Giusti, PhD  
Todd Harper, PhD  
Konstantin Mitgutsch, PhD

Visiting Fellow  
Anamik Saha, PhD
Economics is the study of all those aspects of individual and social activities related to the choice, production, distribution, and consumption of goods and services. In relation to these decisions, economics is concerned with the behavior and interaction of individuals, private firms, and other institutions and government agencies. Economics contributes to the understanding of many important social problems: changes in efficiency and productivity, fluctuations in the overall levels of economic activity and employment, inflation, the effects of government deficits, the growth and decline of industries, changes in foreign exchange rates, increases in international indebtedness, and the behavior of the centrally planned and less developed countries.

Subjects are offered in the major areas of economics: theoretical and applied analysis at the levels of the individual consumer, the firm, and the industry, as well as aggregate economic activity, industrial organization and health economics, econometrics, public finance, urban economics, labor economics and industrial relations, behavioral economics, international trade and finance, economic history, and economic development.

UNDERGRADUATE STUDY

Bachelor of Science in Economics/Course 14

Course 14, leading to the Bachelor of Science in Economics, combines training in technical economics with opportunities for a broad and balanced undergraduate education. Students may choose from a diversified group of undergraduate subjects and are encouraged to engage in independent research.

The aims of the undergraduate degree program are threefold: to give students a firm grounding in modern economic theory and a basic understanding of economic processes; to provide a descriptive knowledge of the US and world economies; and to develop in students the capabilities for quantitative analysis and independent thought. These aims correspond roughly to the requirements in the Course 14 program of theory, electives, statistics and econometrics, and research.

The requirements allow substantial freedom for students in designing individual programs within economics and 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 may select programs that concentrate on economics and other social sciences or may combine economics with other fields. They may emphasize the relation of economics and technology by choosing their free electives in engineering and science, or they may combine their studies in economics with subjects in history and the other humanities.

The successful completion of the degree program prepares students for further study in economics or for careers in business administration and finance, consulting, law and related fields, and public policy.

Although there are several satisfactory alternative subject sequences, students who by the end of their second year have taken 14.01 Principles of Microeconomics and 14.02 Principles of Macroeconomics can follow a program that permits considerable depth in electives in their third and fourth years. The student can complete 14.04 Intermediate Microeconomic Theory, 14.05 Intermediate Applied Macroeconomics, 14.30 Introduction to Statistical Method in Economics, and 14.32 Econometrics in the third year.

This program satisfies the prerequisites for all subjects, including 14.33, and prepares students for research on their thesis and in other elective subjects.

The department specifies one Restricted Electives in Science and Technology (REST) Requirement subject and one laboratory subject, and strongly recommends that students take additional subjects in mathematics if professionally interested in economics.

Minor in Economics

The objective of the minor is to extend the understanding of economic issues beyond the level of the concentration. This is done through specialized analytical subjects and elective subjects that provide an extensive treatment of economic issues in particular areas.

The Minor in Economics consists of six subjects arranged into three levels of study:

 Tier I
  14.01 Principles of Microeconomics*
  14.02 Principles of Macroeconomics*
  and either
  14.30 Introduction to Statistical Method in Economics
  or
  18.05 Introduction to Probability and Statistics

 Tier II
  One subject from the following three:
  14.03 Microeconomic Theory and Public Policy
  14.04 Intermediate Microeconomic Theory
  14.05 Intermediate Applied Macroeconomics

 Tier III
  Two elective undergraduate subjects chosen from the fields of applied economics. A list of specific subjects is available in the Economics Department Office, E52-391.

*Under no circumstances may a student complete a minor with fewer than six subjects. Any student who receives permission from the Economics Department to skip 14.01 and/or 14.02 and take a higher-level subject must take replacement subjects) for 14.01/14.02.

GRADUATE STUDY

Entrance Requirements for Graduate Study

The Department of Economics specifies the following prerequisites for graduate study in economics: one full year of college mathematics and an appreciable number of professional subjects in economics for those qualified students who have majored in fields other than economics.

Applicants for admission who have deficiencies in entrance requirements should consult with the department about programs to remedy such deficits.

Master of Science in Economics

Under special circumstances, admission may be granted to current MIT students seeking the Master of Science degree. The general requirements for the SM are given in the section on Graduate Education in Part 1.


**Doctor of Philosophy**

A candidate for the doctorate must demonstrate a mastery of economic theory, including both microeconomics and macroeconomics, and four other fields of study; achieve a specified level of competence in econometrics; submit and defend a dissertation that represents a contribution to knowledge; and be in residence for a minimum of two years. Two of the four fields, including economic theory, are covered by the written General Examination. Two minor fields may each be satisfied by one year of coursework. The four major and minor elective fields may be chosen from advanced economic theory, econometrics, economic development, economic history, finance, industrial organization, international economics, labor economics, monetary economics, public economics, and urban economics.

There is no required minimum number of graduate subjects in the department. However, candidates ordinarily need two full academic years of study to prepare adequately for the General Examinations and to meet the other pre-thesis requirements. The doctoral thesis must be written in residence, which typically requires three years of research.

**Economics and Urban Studies**

A doctoral program offered jointly by the departments of Economics and Urban Studies and Planning at MIT integrates the analytic emphasis of economics with the institutional and policy orientation of urban studies. Students desiring to enter the program must be admitted to both departments and then explicitly to the joint degree program. Specific requirements for economics are the same as for the economics PhD with only two major fields and one minor, instead of two major and two minor fields. The specific requirements for urban studies are the same as for the PhD except for substitution of an economics general examination field for one of the required urban studies fields. One dissertation is required with acceptance by both departments. The program is administered by an informal standing committee. Further information is available from Professor William C. Wheaton, Room E52-252B, 617-253-1723.

---

**Bachelor of Science in Economics/Course 14**

**General Institute Requirements (GIRs)**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement (three subjects can be satisfied by subjects in the Departmental Program)</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement (one subject can be satisfied by 14.30 in the Departmental Program)</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement (can be satisfied by 14.33 in the Departmental Program)</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

**Total GIR Subjects Required for SB Degree**

| Subjects | 17 |

**Communication Requirement**

The program includes a Communication Requirement of 4 subjects:
- 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H);
- 2 subjects designated as Communication Intensive in the Major (CI-M).

**PLUS Departmental Program**

<table>
<thead>
<tr>
<th>Subject names below are followed by credit units, and by prerequisites if any (corequisites in italics).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects</td>
</tr>
<tr>
<td>Required Subjects</td>
</tr>
<tr>
<td>14.01 Principles of Microeconomics, 12, HASS-S</td>
</tr>
<tr>
<td>14.02 Principles of Macroeconomics, 12, HASS-S</td>
</tr>
<tr>
<td>14.04 Intermediate Microeconomic Theory, 12, HASS-S; 14.01, Calculus II (GIR)</td>
</tr>
<tr>
<td>14.05 Intermediate Applied Macroeconomics, 12, HASS-S, CI-M; 14.01, 14.02</td>
</tr>
<tr>
<td>14.30 Introduction to Statistical Method in Economics, 12, REST, Calculus II (GIR)</td>
</tr>
<tr>
<td>14.32 Econometrics, 12, 14.30</td>
</tr>
<tr>
<td>14.33 Research and Communication in Economics, 12, LAB, CI-M; 14.04, 14.05, 14.32</td>
</tr>
<tr>
<td>14.THU Thesis (15 units), 14.33</td>
</tr>
</tbody>
</table>

**Restricted Electives**

| Elective subjects in economics                                                               |
|                                                                                               |
|                                                                                               |
|                                                                                               |
|                                                                                               |
|                                                                                               |
|                                                                                               |

**Departmental Program Units That Also Satisfy the GIRs**

| Subject names below are followed by credit units                                           |
|                                                                                               |
|                                                                                               |
|                                                                                               |
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|                                                                                               |
|                                                                                               |
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**Unrestricted Electives**

<table>
<thead>
<tr>
<th>Subject names below are followed by credit units, and by prerequisites if any (corequisites in italics).</th>
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</tbody>
</table>

**Total Units Beyond the GIRs Required for SB Degree**

| Units | 180 |

No subject can be counted both as part of the 17-subject GIRs and as part of the 180 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

**Notes**

* Alternate prerequisites and corequisites are listed in the subject description.
* No more than three subjects in economics may be used for the Humanities, Arts, and Social Sciences Requirement.
* Or an approved alternative in statistics.
* May be replaced by an additional elective subject in economics.

For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, [http://student.mit.edu/catalog/index.cgi](http://student.mit.edu/catalog/index.cgi).
Teaching and Research Assistantships
A limited number of students are supported by scholarship and fellowship grants, as well as by teaching and research assistantships. Typically, the assistantships 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
For more information regarding admissions or financial aid, contact Peter Hoagland, 617-253-8787, pvhoag@mit.edu. For undergraduate admissions and academic programs, contact Gary King, 617-253-0951, gking@mit.edu. For any other information, contact Jessica Colón, 617-253-3807, jcolon@mit.edu.

Faculty and Teaching Staff
Whitney K. Newey, PhD
Jane Berkowitz Carlton and Dennis William Carlton Professor of Economics
Department Head
David Autor, PhD
Professor of Economics
Associate Department Head

Professors
K. Daron Acemoglu, PhD
Elizabeth and James Killian Professor of Economics
George-Marios Angeletos, PhD
Professor of Economics
Joshua Angrist, PhD
Ford Professor of Economics
Abhijit Banerjee, PhD
Ford International Professor of Economics
Olivier Blanchard, PhD
Robert M. Solow Professor of Economics
(On leave)
Ricardo J. Caballero, PhD
Ford International Professor of Economics
(On leave)
Victor Chernozhukov, PhD
Professor of Economics
Esther Duflo, PhD
Abdul Latif Jameel Professor of Poverty Alleviation and Development Economics
Glenn D. Ellison, PhD
Gregory K. Palm (1970) Professor of Economics
Amy Finkelstein, PhD
Ford Professor of Economics
Robert S. Gibbons, PhD
Sloan Distinguished Professor of Management and Economics
Michael Greenstone, PhD
3M Professor of Environmental Economics
Jonathan Gruber, PhD
Professor of Economics
Jeffrey E. Harris, MD, PhD
Professor of Economics
Jerry A. Hausman, DPhil
John and Jennie S. MacDonald Professor of Economics
Bengt R. Holmström, PhD
Paul A. Samuelson Professor of Economics
Benjamin Olken, PhD
Professor of Economics
James M. Poterba, DPhil
Mitsui Professor of Economics
Drazen Prelec, PhD
Digital Equipment Corporation Leaders for Global Operations Professor of Management Professor of Management Science and Economics
Nancy L. Rose, PhD
Charles P. Kindleberger Professor of Economics
MacVicar Faculty Fellow
Stephen Ross, PhD
Franco Modigliani Professor of Finance and Economics
Richard L. Schmalensee, PhD
Howard W. Johnson Professor of Economics and Management Professor of Applied Economics
Howard W. Johnson Professor of Economics and Management Professor of Applied Economics
Richard W. Johnson Professor of Economics and Management
Robert Townsend, PhD
Elizabeth and James Killian Professor of Economics

Iván Werning, PhD
Professor of Economics
William C. Wheaton, PhD
Professor of Economics and Urban Studies
Muhamet Yildiz, PhD
Professor of Economics

Associate Professors
Panle Jia Barwich, PhD
Rudi Dornbusch Career Development Associate Professor of Economics
Arnaud Costinot, PhD
Pentti J.K. Kouri Career Development Associate Professor of Economics
Guido Lorenzoni, PhD
Associate Professor of Economics
Anna Mikusheva, PhD
Associate Professor of Economics

Assistant Professors
Dave Donaldson, PhD
Assistant Professor of Economics
Mihai Manea, PhD
Assistant Professor of Economics
Paulo Somaini, PhD
Assistant Professor of Economics
Juuso Toikka, PhD
Assistant Professor of Economics
(On leave)
Heidi Williams, PhD
Assistant Professor of Economics

Visiting Professors
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Visiting Professor of Economics
Eliana La Ferrara, PhD
Visiting Professor of Economics
Jawwad Noor, PhD
Visiting Associate Professor of Economics
Jean Tirole, PhD
Visiting Professor of Economics
Senior Lecturer
Sara Fisher Ellison, PhD

Professors Emeriti
Morris A. Adelman, PhD
Professor of Economics, Emeritus

Robert L. Bishop, PhD
Professor of Economics, Emeritus

Peter A. Diamond, PhD
Institute Professor, Emeritus

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Stanley Fischer, PhD
Professor of Economics, Emeritus

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Institute Professor, Emeritus

Peter Temin, PhD
Elisha Gray II Professor of Economics, Emeritus

Lester C. Thurow, PhD
Jerome and Dorothy Lemelson Professor of Management and Economics, Emeritus
The Foreign Languages and Literatures Section offers a variety of programs. There are subject sequences in Chinese, French, German, Japanese, Portuguese, and Spanish languages and literatures taught in the original; a subject sequence on literature in English translation (SILC); studies in bilingualism; and a comprehensive program in English Language Studies.

The Foreign Languages and Literatures curriculum is arranged in three tiers. Fundamental language subjects familiarize students with the principles of the language in both its spoken and written forms, and introduce them to the culture of the country where the language is spoken. Levels III and IV language subjects provide review and refinement of grammar, study of more difficult reading matter with cultural and literary content, and include compositions and discussions in the foreign language.

Subjects in language, literature, and culture are conducted in the foreign language. They introduce students to the form and content of foreign literatures and of foreign cultures and societies. These subjects also offer the opportunity to develop more refined communication skills in the language. Advanced subjects, conducted in the foreign language, encourage students to explore the cultural history of the particular country in which the language is spoken.

Offerings in Studies in International Literatures and Cultures (SILC), taught in English, give students both a specific and comparative focus on foreign cultures.

Concentrations are available in a given language, literature, or culture in the original language or in English. Concentrations should be arranged on an individual basis in consultation with a designated advisor in each language group.

The Minor Programs in Chinese, French, German, Japanese, and Spanish lead students who have already reached an intermediate level of proficiency into more advanced study of the language, literature, and culture. Note that language levels I and II do not count toward the minor. Also note that, unlike other minor programs in HASS, the minor advisor in each of these languages can, at his or her discretion, approve a minor in which MIT subjects comprise at least one-third of the subjects of the program. However, this exception to the general HASS Minor Requirement is only allowed in those cases in which students have received transfer credits equal to four subjects through study abroad in a country where the language of the minor is the dominant tongue.

**Bachelor of Science in Foreign Languages and Literatures/Course 21F**

Program I in French Studies and Program II in Spanish Studies are designed to provide: competence in reading, writing, and speaking; general knowledge of French or Spanish culture and literature; and advanced subjects in literature, film, and cultural studies.

For either option, each student designs a program in consultation with an advisor in order to meet individual interests, abilities, and goals. However, all majors reflect a balance of historical, geographical, cultural, and linguistic competence.

**Minor Programs**

The Minor in Chinese typically consists of six subjects arranged into three levels of study as follows:

**Tier I** Two language subjects at the intermediate level:
- 21F.103/21F.173 Chinese III (Regular)
- 21F.104 Chinese IV (Regular)
- or 21F.109/21F.183 Chinese III (Streamlined)
- 21F.110 Chinese IV (Streamlined)
- or 21F.142 Intermediate Chinese I: Very Fast Track
- 21F.143 Intermediate Chinese II: Very Fast Track

**Tier II** Two language subjects at the advanced level:
- 21F.105/21F.175 Chinese V (Regular)
- 21F.106 Chinese VI (Regular)
- or 21F.113/21F.185 Chinese V (Streamlined)
- Students in the Streamlined sequence of subjects (as opposed to Regular) should consult with the minor advisor about the special options for them to fulfill the Tier II requirement.

**Tier III** Two subjects in Chinese literature, history, or culture, at least one of which must be a Chinese Language Option subject, i.e., 21F.190, 21F.192, 21F.193, 21F.194, or 21F.195. The Chinese Language Option (CLO) subjects meet with the five subjects 21F.036, 21F.046, 21F.050, 21F.058, and 21F.044, respectively, and include some assignments that require reading and writing in Chinese. Students taking the Streamlined track may use the capstone subject 21F.199 instead of the regular Chinese Language Option subjects.

21F.027 Asia in the Modern World: Images and Representations
21F.030/21F.193 East Asian Culture: From Zen to Pop
21F.036/21F.190 Advertising and Popular Culture: East Asian Perspectives
21F.038/21F.194 The Cultural Politics of Contemporary China
21F.043J Introduction to Asian American Studies: Historical and Contemporary Issues
21F.044/21F.195 Classics of Chinese Literature in Translation
21F.046/21F.192 Modern Chinese Literature and Cinema
21F.075J The Global Chinese: Chinese Migration, 1567 to Present
21H.151 Traditional China: Earliest Times to 1644
21H.152 Modern China: 1644 to Present
21H.351J Shanghai and China’s Modernization

Capstone Subject 21F.199 Chinese Youths and Web Culture

The Minor in French consists of six subjects arranged into three levels of study as follows:

**Tier I** Two subjects or fewer depending on demonstrated level of entering competence:
- 21F.303/21F.373 French III
- 21F.304/21F.374 French IV

**Tier II** Two or three subjects from the following intermediate subjects in French language, literature, and culture: 21F.308–21F.315 (with the exception of 21F.314)

**Tier III** Two or three subjects from the following advanced subjects in French literature and culture: 21F.052, 21F.068J, 21F.071, 21F.320–21F.348, and 21H.241
Bachelor of Science in Foreign Languages and Literatures/Course 21F

General Institute Requirements (GIRs) | Subjects |
Science Requirement | 6 |
Humanities, Arts, and Social Sciences Requirement [three subjects may be satisfied by subjects in the Departmental Program] | 8 |
Restricted Electives in Science and Technology (REST) Requirement | 2 |
Laboratory Requirement | 1 |
Total GIR Subjects Required for SB Degree | 17 |

Communication Requirement
The program includes a Communication Requirement of 4 subjects:
2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and
2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program | Units |
Program 1: French Studies | (2q) |
Prerequisite subjects: 21F.301, 21F.302 | 42 |
Required Subjects | |
21F.304 French IV, 12, HASS-H†, 21F.303* | |
To satisfy the requirement that students complete two Communication Intensive subjects in the major, students must take 21F.306 and 21F.307. Registration for 21F.306 and 21F.307 must be simultaneous with one of the following: 21F.308, 21F.310, 21F.311, 21F.312, 21F.313, 21F.316, 21F.321, 21F.323, 21F.341, or 21F.346.
Restricted Electives | 90 |
A coherent program of 8 subjects beyond French II from the French curriculum, which may include a pre-thesis tutorial and a thesis.

Program 2: Spanish Studies | (2q) |
Prerequisite subjects: 21F.701, 21F.702 | 42 |
Required Subjects | |
21F.704 Spanish IV, 12, HASS-H†, 21F.703* | |
To satisfy the requirement that students complete two Communication Intensive subjects in the major, students must take 21F.708 and 21F.709. Registration for 21F.708 and 21F.709 must be simultaneous with one of the following range of subjects: 21F.716, 21F.721, 21F.730, 21F.735, 21F.736, 21F.738, or 21F.740.
Restricted Electives | 90 |
A coherent program of 8 subjects beyond Spanish II from the Spanish curriculum, which may include a pre-thesis tutorial and a thesis.

Departmental Program Units That Also Satisfy the GIRs | (36) |
Unrestricted Electives (for Each Program) | 48 |

Total Units Beyond the GIRs Required for SB Degree | 180 |
No subject can be counted both as part of the 17-subject GIRs and as part of the 180 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

Notes
* Alternate prerequisites and corequisites are listed in the subject description.
† Students who entered prior to fall 2010 may use this subject to satisfy the HASS-D requirement.
For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.

The Minor in German consists of six subjects arranged into three levels of study as follows:

Tier I Two subjects or fewer depending on demonstrated level of entering competence:
21F.403/21F.473 German III
21F.404/21F.474 German IV

Tier II Two or three subjects from the intermediate subjects in German language, literature, and culture:
21F.405–21F.412

Tier III Two or three subjects from 21F.019, 21F.055, 21F.059, 21F.081, and 21F.414–21F.420

The Minor in Japanese consists of six subjects arranged into three levels of study as follows:

Tier I Two language subjects at the intermediate level:
21F.503/21F.573 Japanese III
21F.504 Japanese IV or
21F.562 Intermediate Japanese I: Very Fast Track
21F.563 Intermediate Japanese II: Very Fast Track

Tier II Two language subjects at the advanced level:
21F.505/21F.575 Japanese V
21F.506 Japanese VI

Tier III Two subjects in Japanese literature, history, or culture, at least one of which must be a Japanese Language Option subject, i.e., 21F.590, 21F.591, 21F.592, 21F.593, or 21F.596. The Japanese Language Option subjects meet with the five subjects, 21F.0271, 21F.039, 21F.063, 21F.064, and 21F.065, and include some assignments that require reading and writing in Japanese.

17.433 International Relations of East Asia
17.537 Politics and Policy in Contemporary Japan
17.543 Japanese Politics and Society
The Minor in Spanish consists of six subjects arranged into three levels of study as follows:

**Tier I**

Two subjects or fewer depending on demonstrated level of entering competence:
- 21F.703/21F.773 Spanish III
- 21F.704/21F.774 Spanish IV

**Tier II**

Three subjects or fewer depending on demonstrated level of entering competence from the Spanish Intermediate Subjects in Language, Literature, and Culture listing: 21F.711–21F.714, and 21F.792

**Tier III**

Two subjects or more depending on demonstrated level of entering competence from the Spanish Advanced Subjects in Literature and Culture listing: 21F.010, 21F.084J, 21F.716–21F.740

Please also refer to the Minor in Applied International Studies and the HASS Minors in Regional Studies, which include African and African Diaspora Studies, Asian and Asian Diaspora Studies, Latin American and Latino Studies, Middle Eastern Studies, and Russian and Eurasian Studies, in Part 3.

**Other Degree Programs**

A degree program is offered in German (Course 21). Joint degree programs are offered in French, German, and Spanish, and include majors in combination with a field in engineering or science (21E, 21S). See the Department of Humanities section for further information.

**Inquiries**

Further information on subjects and programs may be obtained from the Foreign Languages and Literatures Section Office, Room 14N-305, 617-253-4771.

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**FACULTY AND STAFF**

**Faculty and Teaching Staff**

- Shigeru Miyagawa, PhD  
  Kochi Prefecture-John Manjiro Professor of Japanese Language and Culture  
  Professor of Linguistics  
  Section Head

**Professors**

- Elizabeth Garrels, PhD  
  Professor of Spanish and Latin American Studies
- William Uricchio, PhD  
  Professor of Comparative Media Studies  
  Director, Comparative Media Studies Program
- Jing Wang, PhD  
  Professor of Chinese Cultural Studies  
  S. C. Fang Professor of Chinese Language and Culture

**Associate Professors**

- Ian Condry, PhD  
  Mitsui Career Development Associate Professor of Japanese Cultural Studies
- Margery Resnick, PhD  
  Associate Professor of Hispanic Studies
- Emma Teng, PhD  
  Associate Professor of Chinese Studies and History  
  T. T. and Wei Fong Professor of Asian Civilizations

**Assistant Professor**

- Bruno Perreau, PhD  
  Assistant Professor of French Studies

**Senior Lecturers**

- Ellen Crocker, MA  
  Senior Lecturer in German
- Jane Dunphy, MA  
  Senior Lecturer in English Language Studies
- Margarita Ribas Groeger, MA  
  Senior Lecturer in Spanish  
  Director, Spanish Language Studies
- Sabine Levet, MA  
  Senior Lecturer in French  
  Undergraduate Academic Officer

**Lecturers**

- Tong Chen, MA  
  Lecturer in Chinese
- Cathy Culot, MA  
  Lecturer in French
- Nils Dominique, PhD  
  Lecturer in Portuguese
- Dagmar Jaeger, PhD  
  Lecturer in German
- A. C. Kemp, MA  
  Lecturer in English Language Studies
- Masami Ikeda Lamm, MA  
  Lecturer in Japanese
- Min-Min Liang, MA  
  Lecturer in Chinese
- Yoshimi Nagaya, MA  
  Lecturer
  Director, Japanese Language Studies
- Roberto Rey Agudo, PhD  
  Lecturer in Spanish
- Leanna Rezvani, PhD  
  Lecturer in French
- Lissette Soto, MA  
  Lecturer in Spanish
- Peter Weise, PhD  
  Lecturer in German
- Ana Yañez, PhD  
  Lecturer in Spanish
- Jin Zhang, MA  
  Lecturer in Chinese

**Faculty Emeriti**

- Catherine Vakar Chvany, PhD  
  Professor of Russian Studies, Emerita
- Isabelle de Courtivron, PhD  
  Professor of French Studies, Emerita
- Gilberte Furstenberg, Agrégation  
  Senior Lecturer in French, Emerita
- James Wesley Harris, PhD  
  Professor of Spanish and Linguistics, Emeritus
- Douglas Morgenstern, MA  
  Senior Lecturer in Spanish, Emeritus
- Edward Baron Turk, PhD  
  Professor of French Studies and Film John E. Burchard Professor of Humanities, Emeritus
History is the study of the recorded past. Since interest in the past is closely linked with a desire to understand the present, the history curriculum at MIT is tailored in part to put the modern world in historical perspective. Subjects explore the social, cultural, economic, and political transformations that shape the present; and efforts are made to suggest where traditional assumptions remain in present-day politics, society, and culture.

The curriculum seeks to encourage both an understanding of the human past and the development of skills necessary to express that knowledge effectively.

Bachelor of Science in History/
Course 21H

The program leading to the degree of Bachelor of Science in History is designed to encourage students to discover and reconstruct the past, to confront and understand the complexity of past human behavior for itself, and to inform their sense of the historical present. The curriculum includes the selection of at least one subject taken from the curriculum’s 21H undergraduate seminars. Students are expected to take seven additional subjects of their own choice, selected in consultation with a major advisor. These must include subjects drawn from at least two geographical areas, as well as one pre-modern (before 1700) and one modern subject.

During the junior year, the history major is required to take subject 21H.390 Seminar in Historical Methods, which is intended to develop skills for independent research and writing, followed in the senior year by 21H.ThT History Pre-Thesis Tutorial and 21H.ThU History Thesis. Subjects 21H.390 and 21H.ThU satisfy the CI-M component of the Communication Requirement. Supplementing these requirements within the history curriculum is the stipulation of three additional subjects in a second field of humanities, arts, and social sciences that provide the perspectives of another discipline on the history of human thought and behavior. This program is intentionally flexible; the relatively large number of electives and unrestricted time allows for the design of a course of study that meets individual needs and interests.

Minor in History

The goal of this minor is to lead the student from basic survey subjects into more focused studies of individual countries or periods of time, and to encourage thinking about broader analytical and comparative issues in historical study.

The Minor in History consists of six subjects, which must include:

- Four undergraduate introductory or intermediate subjects from the history curriculum
- 21H.390 Seminar in Historical Methods
- At least one 21H seminar in addition to 21H.390
- At least two temporal periods—one pre-modern (before 1700) and one modern—to be covered by the five subjects other than 21H.390

For a listing of available subjects, consult the History Office, Room E51-255, 617-324-5134.

Concentration in History

The Concentration in History consists of three 21H subjects.

Minor in Applied International Studies

A range of subjects in history can fulfill requirements for the interdisciplinary Minor in Applied International Studies. For more information about this minor, see the program description under Interdisciplinary Undergraduate Programs and Minors in Part 3.

Joint Degree Programs

Joint degree programs are offered in history in combination with a field in engineering or science (21E, 21S). See the joint degree programs listed under Humanities.

Subjects in History are described in the online MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi. Further information on subjects and programs may be obtained from the History Office, Room E51-255, 617-324-5134.
Bachelor of Science in History/Course 21H

General Institute Requirements (GIRs)  

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement (three subjects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>can be satisfied by subjects in the Departmental Program)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total GIR Subjects Required for SB Degree</td>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>

Communication Requirement  

The program includes a Communication Requirement of 4 subjects:  
2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and  
2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program  

<table>
<thead>
<tr>
<th>Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Subjects</td>
</tr>
<tr>
<td>One 21H seminar subject (9–12 units)</td>
</tr>
<tr>
<td>21H.TDP Seminar in Historical Methods, 12, CI-M, HASS-H *</td>
</tr>
<tr>
<td>21H.THT History Pre-Thesis Tutorial, 12</td>
</tr>
<tr>
<td>21H.THU History Thesis, 12, CI-M *</td>
</tr>
<tr>
<td>Restricted Electives</td>
</tr>
<tr>
<td>A coherent program of seven subjects from the history curriculum; and three related subjects from a second</td>
</tr>
<tr>
<td>HASS discipline.</td>
</tr>
</tbody>
</table>

Departmental Program Units That Also Satisfy the GIRs  

<table>
<thead>
<tr>
<th>Unit count (27–33)</th>
<th></th>
</tr>
</thead>
</table>

Unrestricted Electives  

<table>
<thead>
<tr>
<th>Unit count (48–72)</th>
<th></th>
</tr>
</thead>
</table>

Total Units Beyond the GIRs Required for SB Degree  

<table>
<thead>
<tr>
<th>Unit count 180</th>
<th></th>
</tr>
</thead>
</table>

Notes  

*Prerequisites and corequisites are listed in the subject description.

For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule,  
The Department of Humanities consists of six autonomous sections and programs, each with its own headquarters: Anthropology, Foreign Languages and Literatures, History, Literature, Music and Theater Arts, and Writing and Humanistic Studies.

In addition to the degrees offered in the six sections, other undergraduate degree programs are available in Course 21, either in combination with a field in engineering or science (as 21E or 21S composite majors) or as full majors (as Course 21 major departures), described later in this section. Students interested in any of these degree programs should consult an advisor in the field, as well as the section or program office.

**MAJOR DEPARTURE**

**Bachelor of Science in Humanities/Course 21**

The Bachelor of Science in Humanities degree provides an option for students who wish to pursue their humanistic studies extensively and at an advanced level. This degree is received by students completing a Course 21 major departure or majoring in German. The major departure is a major by special arrangement, requiring approval by the Dean of the School of Humanities, Arts, and Social Sciences, in one of the following fields:

- American Studies
- Ancient and Medieval Studies
- Asian and Asian Diaspora Studies
- Latin American and Latino Studies
- Russian and Eurasian Studies
- Theater Arts
- Women’s and Gender Studies

### General Institute Requirements (GiRs)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement [all but two Humanities, Arts, and Social Sciences Distribution subjects can be satisfied by subjects in the Departmental Program]</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Total GIR Subjects Required for SB Degree</strong></td>
<td></td>
<td><strong>17</strong></td>
</tr>
</tbody>
</table>

### Communication Requirement

The program includes a Communication Requirement of 4 subjects:
- 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and
- 2 subjects designated as Communication Intensive in the Major (CI-M).

### PLUS Departmental Program

<table>
<thead>
<tr>
<th>Subject Name</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restricted Electives</td>
<td><strong>126–162</strong></td>
</tr>
<tr>
<td>German</td>
<td></td>
</tr>
<tr>
<td>Eight elective subjects in the field (which may include a pre-thesis and a thesis), plus a four-subject cluster[ii]</td>
<td></td>
</tr>
</tbody>
</table>

To satisfy the requirement that students complete two Communication Intensive subjects in the major, students must take 21F.406 and 21F.407. Registration for 21F.406 and 21F.407 must be simultaneous with one of 21F.409, 21F.410, 21F.412, 21F.414, 21F.415, 21F.416, or 21F.420.

### Major Departures

The restricted electives for the major departure fields are determined in consultation with the faculty advisor in the chosen field. Major departures are available in American Studies, Ancient and Medieval Studies, Asian and Asian Diaspora Studies, Latin American and Latino Studies, Russian and Eurasian Studies, Theater Arts, and Women’s and Gender Studies.

Each major departure program must include two Communication Intensive major subjects, usually chosen from the subjects designated as CI-M for major programs in adjacent disciplines. Students must designate CI-M subjects by petitioning the Subcommittee on the Communication Requirement.

### Departmental Program Units That Also Satisfy the GiRs

<table>
<thead>
<tr>
<th>Subject Name</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>(27–36)</td>
<td></td>
</tr>
<tr>
<td>Unrestricted Electives</td>
<td><strong>45–90</strong></td>
</tr>
</tbody>
</table>

### Total Units Beyond the GiRs Required for SB Degree

180

No subject can be counted both as part of the 17-subject GiRs and as part of the 180 units required beyond the GiRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

### Notes

\[i\] Only one subject used to meet the distribution element of the Humanities, Arts, and Social Sciences Requirement may be counted toward the humanities component of these degree programs.

\[ii\] The cluster is usually formed within a single second discipline of the humanities, arts, or social sciences. In special cases, it may draw together subjects from different disciplines to form a coherent grouping.

For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, [http://student.mit.edu/catalog/index.cgi](http://student.mit.edu/catalog/index.cgi).
Bachelor of Science in Humanities and Engineering/Course 21E,
Bachelor of Science in Humanities and Science/Course 21S

General Institute Requirements (GIRs)(1) Subjects
Science Requirement
Humanities, Arts, and Social Sciences Requirement [all but two Humanities, Arts, and Social Sciences Distribution subjects can be satisfied by subjects in the Departmental Program] 8
Restricted Electives in Science and Technology (REST) Requirement 2
Laboratory Requirement 1
Total GIR Subjects Required for SB Degree 17

Communication Requirement
The program includes a Communication Requirement of 4 subjects:
2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and
2 subjects designated as Communication Intensive in the Major (CI-M). Students must designate CI-M subjects by petitioning the Subcommittee on the Communication Requirement. Each 21E and 21S program must include two CI-M subjects. Normally, students are expected to complete one CI-M from each area of study, usually chosen from the subjects designated as CI-M for the full major.

PLUS Departmental Program
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

Restricted Electives
For the humanities component, one of the following (further details may be obtained from the descriptions of programs in specific fields and the relevant field office):
American Studies(5)
Seven elective subjects (including two in history and two in literature), a pre-thesis tutorial, and a thesis. Students may submit a request to the American Studies faculty advisor to substitute two classes in lieu of the pre-thesis and thesis.
Ancient and Medieval Studies(6)
Seven elective subjects (should follow the general structure of the Ancient and Medieval Studies Minor Program), a pre-thesis tutorial, and a thesis.
Anthropology
Nine subjects including 21A.00 or 21A.01, 21A.802, and 21A.852. An honors thesis may be done at the invitation and approval of faculty.
Asian and Asian Diaspora Studies(7)
Seven elective subjects (should follow the general structure of the Asian and Asian Diaspora Studies Minor program), a pre-thesis tutorial, and a thesis.
Comparative Media Studies
Eight CMS subjects, including 21L.011 or CMS.100, one mid-tier subject (CMS.400, CMS.403), CMS.405, or CMS.407, one capstone subject (21L.706 or 21L.771), and five CMS electives. A pre-thesis tutorial (CMS.ThT) and thesis (CMS.ThU) may be substituted for one CMS elective.
Foreign Languages and Literatures (in French, German, or Spanish)
Nine elective subjects, which may include a pre-thesis and thesis, subject to faculty approval.
History
Seven elective subjects, a pre-thesis tutorial, and a thesis.
Latin American and Latino Studies
Nine subjects including 21A.00 or 21A.01, 21A.802, and 21A.852. An honors thesis may be done at the invitation and approval of faculty.
Music
Four subjects (21M.301, 21M.302, 21M.500, and one of the following: 21M.220, 21M.235, 21M.250, or 21M.260), two terms of performance subjects, electives in two categories (usually theory/composition and history/literature), and a third elective in any category (theory/composition, history/literature, or two terms of performance).
Russian and Eurasian Studies
Seven elective subjects (including Russian language requirement), a pre-thesis tutorial, and a thesis.

Notes:
(1) PLUS Departmental Program
(2) Science Requirement
(3) Humanities, Arts, and Social Sciences Requirement
(4) REST Requirement
(5) Communication Requirement
(6) CI-M
(7) CI-H

Restricted Electives in Science and Technology (REST) Requirement

Science Requirement
Humanities, Arts, and Social Sciences Requirement [all but two Humanities, Arts, and Social Sciences Distribution subjects can be satisfied by subjects in the Departmental Program] 8
Restricted Electives in Science and Technology (REST) Requirement 2
Laboratory Requirement 1
Total GIR Subjects Required for SB Degree 17

Communication Requirement
The program includes a Communication Requirement of 4 subjects:
2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and
2 subjects designated as Communication Intensive in the Major (CI-M). Students must designate CI-M subjects by petitioning the Subcommittee on the Communication Requirement. Each 21E and 21S program must include two CI-M subjects. Normally, students are expected to complete one CI-M from each area of study, usually chosen from the subjects designated as CI-M for the full major.

PLUS Departmental Program
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

Restricted Electives
For the humanities component, one of the following (further details may be obtained from the descriptions of programs in specific fields and the relevant field office):
American Studies(5)
Seven elective subjects (including two in history and two in literature), a pre-thesis tutorial, and a thesis. Students may submit a request to the American Studies faculty advisor to substitute two classes in lieu of the pre-thesis and thesis.
Ancient and Medieval Studies(6)
Seven elective subjects (should follow the general structure of the Ancient and Medieval Studies Minor Program), a pre-thesis tutorial, and a thesis.
Anthropology
Nine subjects including 21A.00 or 21A.01, 21A.802, and 21A.852. An honors thesis may be done at the invitation and approval of faculty.
Asian and Asian Diaspora Studies(7)
Seven elective subjects (should follow the general structure of the Asian and Asian Diaspora Studies Minor program), a pre-thesis tutorial, and a thesis.
Comparative Media Studies
Eight CMS subjects, including 21L.011 or CMS.100, one mid-tier subject (CMS.400, CMS.403), CMS.405, or CMS.407, one capstone subject (21L.706 or 21L.771), and five CMS electives. A pre-thesis tutorial (CMS.ThT) and thesis (CMS.ThU) may be substituted for one CMS elective.
Foreign Languages and Literatures (in French, German, or Spanish)
Nine elective subjects, which may include a pre-thesis and thesis, subject to faculty approval.
History
Seven elective subjects, a pre-thesis tutorial, and a thesis.
Latin American and Latino Studies
Nine subjects including 21A.00 or 21A.01, 21A.802, and 21A.852. An honors thesis may be done at the invitation and approval of faculty.
Music
Four subjects (21M.301, 21M.302, 21M.500, and one of the following: 21M.220, 21M.235, 21M.250, or 21M.260), two terms of performance subjects, electives in two categories (usually theory/composition and history/literature), and a third elective in any category (theory/composition, history/literature, or two terms of performance).
Russian and Eurasian Studies
Seven elective subjects (including Russian language requirement), a pre-thesis tutorial, and a thesis.

Notes:
(1) PLUS Departmental Program
(2) Science Requirement
(3) Humanities, Arts, and Social Sciences Requirement
(4) REST Requirement
(5) Communication Requirement
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(7) CI-H

Restricted Electives in Science and Technology (REST) Requirement

Science Requirement
Humanities, Arts, and Social Sciences Requirement [all but two Humanities, Arts, and Social Sciences Distribution subjects can be satisfied by subjects in the Departmental Program] 8
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Laboratory Requirement 1
Total GIR Subjects Required for SB Degree 17

Communication Requirement
The program includes a Communication Requirement of 4 subjects:
2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and
2 subjects designated as Communication Intensive in the Major (CI-M). Students must designate CI-M subjects by petitioning the Subcommittee on the Communication Requirement. Each 21E and 21S program must include two CI-M subjects. Normally, students are expected to complete one CI-M from each area of study, usually chosen from the subjects designated as CI-M for the full major.

PLUS Departmental Program
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

Restricted Electives
For the humanities component, one of the following (further details may be obtained from the descriptions of programs in specific fields and the relevant field office):
American Studies(5)
Seven elective subjects (including two in history and two in literature), a pre-thesis tutorial, and a thesis. Students may submit a request to the American Studies faculty advisor to substitute two classes in lieu of the pre-thesis and thesis.
Ancient and Medieval Studies(6)
Seven elective subjects (should follow the general structure of the Ancient and Medieval Studies Minor Program), a pre-thesis tutorial, and a thesis.
Anthropology
Nine subjects including 21A.00 or 21A.01, 21A.802, and 21A.852. An honors thesis may be done at the invitation and approval of faculty.
Asian and Asian Diaspora Studies(7)
Seven elective subjects (should follow the general structure of the Asian and Asian Diaspora Studies Minor program), a pre-thesis tutorial, and a thesis.
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Nine elective subjects, which may include a pre-thesis and thesis, subject to faculty approval.
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Seven elective subjects, a pre-thesis tutorial, and a thesis.
Latin American and Latino Studies
Nine subjects including 21A.00 or 21A.01, 21A.802, and 21A.852. An honors thesis may be done at the invitation and approval of faculty.
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Seven elective subjects (including Russian language requirement), a pre-thesis tutorial, and a thesis.

Notes:
(1) PLUS Departmental Program
(2) Science Requirement
(3) Humanities, Arts, and Social Sciences Requirement
(4) REST Requirement
(5) Communication Requirement
(6) CI-M
(7) CI-H

Restricted Electives in Science and Technology (REST) Requirement
Students may take Course 21E or Course 21S as part of the double major program outlined in the section on Undergraduate Education in Part 1. However, because 21E and 21S are composite degrees, a second major is not allowed in either field of a student’s chosen program. For example, if a student pursues a 21S degree with the Science portion in Course 8, the student would not be permitted to apply for a second major in Course 8. Similarly, if the Humanities portion of the 21S degree were in Course 21L, the student could not apply for a second major in Course 21L.

| Science, Technology, and Society (STS) | 96–114 |
| Eight subjects (including at least one STS Tier I subject, at least one Tier II subject, and STS.091), plus a pre-thesis tutorial and a thesis. |

| Theater Arts | 90–108 |
| Eight subjects (including Script Analysis, Theater Practicum, and Stagecraft), a pre-thesis tutorial, and a thesis. |

| Women’s and Gender Studies | 81–102 |
| Seven subjects (including WGS.101 Introduction to Women’s and Gender Studies), a pre-thesis tutorial, and a thesis. Students may submit a request to the Women’s and Gender Studies director to substitute two classes in lieu of the thesis and pre-thesis. |

| Writing: Creative | 93–102 |
| Seven subjects centered in creative or expository writing (one of these subjects is normally at the introductory level, one may be chosen from a related field), a pre-thesis tutorial, and a thesis. |

| Writing: Digital Media | 93–102 |
| Three subjects in digital media (21W.764, 21W.765j, and 21W.785), a CI-M subject in writing, and three related subjects from another department. |

| Writing: Science Writing | 96–102 |
| Six subjects in writing (including 21W.777, 21W.778, 21W.792, a subject in basic exposition, and a subject in digital media), one approved science, technology, and society subject, a pre-thesis tutorial, and a thesis. |

And for the engineering/science component, one of the following:

For 21E
Six elective subjects restricted to one of the engineering curricula and approved by a faculty member in the field.

For 21S
Six elective subjects restricted to one of the science curricula and approved by a faculty member in the field.

Departmental Program Units That Also Satisfy the GIRs

| 54–72 |

Unrestricted Electives

| 54–103 |

Total Units Beyond the GIRs Required for SB Degree

| 180 |

No subject can be counted both as part of the 17-subject GIRs and as part of the 180 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

### Notes on 21E and 21S

1. As a matter of general Course 21 policy, subjects used to meet the General Institute Science Requirement, the REST Requirement, and the Laboratory Requirement may not be included in the six-subject Engineering or Science component of 21E or 21S degrees. Only one subject being used to meet the distribution element of the Humanities, Arts, and Social Sciences Requirement may be counted toward the humanities component of these degree programs.

2. American Studies, Ancient and Medieval Studies, Asian and Asian Diaspora Studies, Latin American and Latino Studies, Russian and Eurasian Studies, Theater Arts, and Women’s and Gender Studies are also available as full majors by special arrangement with the Dean of the School of Humanities, Arts, and Social Sciences.

3. Russian language subjects are not offered at MIT, but may be taken at Harvard University or Wellesley College through cross-registration.

4. When possible, the subject satisfying the Institute Laboratory Requirement and one of the subjects satisfying the REST Requirement should be selected from this same curriculum, in addition to the regular requirement.

For an explanation of credit units, or hours, please refer to the online help in the MIT Subject Listing & Schedule, [http://student.mit.edu/catalog/index.cgi](http://student.mit.edu/catalog/index.cgi).
As its name suggests, the Department of Linguistics and Philosophy houses a linguistics section and a philosophy section. Though they share a number of intellectual interests and a joint undergraduate major, these two sections are administratively autonomous with separate chairpersons, faculties, admissions procedures, curricular and degree requirements, and financial aid programs.

**UNDERGRADUATE STUDY**

**Bachelor of Science in Philosophy/Course 24-1**

This major is designed to provide familiarity with the history and current status of the main problems in epistemology, metaphysics, and ethics; mastery of some of the technical skills requisite for advanced work in philosophy; faculty at independent philosophical study; and 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 Linguistics and Philosophy/Course 24-2**

This major, also known as the Program in Language and Mind, aims to provide students with a working knowledge of a variety of issues that currently occupy the intersection of philosophy, linguistics, and cognitive science. Central among these topics are the nature of language, of those mental representations that we call “knowledge” and “belief,” and of the innate basis for the acquisition of certain types of knowledge (especially linguistic knowledge). Students have the option of pursuing either a philosophy track or a linguistics track. Both require a core set of subjects drawn from both fields and are designed to teach students the central facts and issues in the study of language and the representation of knowledge. Each track requires, in addition, a set of subjects drawn primarily from its discipline and is designed to prepare students for graduate study either in philosophy/cognitive science or in linguistics. A coherent program of three restricted electives (drawn from one or two of the following three areas: linguistics, philosophy, or a related area) rounds out the major.

Note that students are prohibited from majoring in both 24-1 and 24-2.
Minors

The goal of the Minor in Philosophy is to introduce students to the methods of analytic philosophy and then to have them study a broad range of philosophers and philosophical issues at a more sophisticated level, culminating in an advanced seminar.

The minor consists of six subjects arranged into three levels of study as follows:

Tier I

Two subjects:
- Any CI-H philosophy subject
- A logic subject (24.118 Paradox and Infinity, 24.241 Logic I, 24.242 Logic II, 24.243 Classical Set Theory, 24.244 Modal Logic, 24.245 Theory of Models, or a logic subject in another department, e.g., Mathematics, if approved by the minor advisor)

Tier II

Three non-introductory philosophy subjects, approved by the minor advisor

Tier III

One subject:
- Topics in Philosophy

Tier II

Three subjects:
- Language and Its Structure I: Phonology
- Language and Its Structure II: Syntax
- Language and Its Structure III: Semantics and Pragmatics

Tier III

Two subjects chosen from:
- Language Acquisition
- Psycholinguistics
- The Linguistic Study of Bilingualism
- Abnormal Language
- Field Methods in Linguistics
- Advanced Topics in Linguistic Analysis
- Language Variation and Change
- Linguistic Phonetics

GRADUATE STUDY

Master of Science in Linguistics

The Department of Linguistics and Philosophy has an Indigenous Language Initiative program leading to a Master of Science in Linguistics. For more information about this experimental degree, visit the website at http://web.mit.edu/linguistics/www/mitili/ or contact the program administrator at mitili@mit.edu.

Doctor of Philosophy in Linguistics

The Linguistics Section offers a demanding program leading to the degree of Doctor of Philosophy in Linguistics. The normal course of study is four or five years, including the writing of the dissertation. The orientation of the program is highly theoretical, its central aim being the development of a general theory that reveals the rules and laws that govern the structure of a given language and the general laws and principles that govern all natural languages. The topics that form the core of this program are the traditional ones of phonology, syntax, and semantics, but the program's interests also extend into questions of the interrelations between linguistics and other disciplines such as philosophy and logic, speech science and technology, computer science and artificial intelligence, and study of the brain and cognition.

Approximately eight students enter the program each year in a highly selective admissions process. 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 scholarly inquiry of complex subject matter.

All students in the linguistics program must complete a set of required subjects unless they have acquired adequate preparation elsewhere. Before degree candidates begin their doctoral research, they are required to pass a comprehensive general examination, in conformity with Institute requirements. Students must also demonstrate competence in one foreign language.

The following subjects are normally required of all doctoral candidates in linguistics:

- Introduction to Syntax
- Introduction to Phonology
- Introduction to Semantics
- Survey of General Linguistics
- Advanced Syntax
- Advanced Phonology
- Advanced Semantics
- Tutorial in Linguistics and Related Fields
- Topics in the Grammar of a Less Familiar Language
- Language Acquisition I
- Workshop in Linguistics (two terms)

Before students begin their doctoral research, they are required to pass a comprehensive general examination that is composed of two parts. The first part is a written examination consisting of two substantial papers on topics chosen in consultation with members of the
faculties. The two papers must present research on two distinct topics in two distinct subdisciplines of linguistics. The subdisciplines include phonetics, phonology, syntax, semantics, pragmatics, language acquisition, language processing, or any other area of linguistics, so long as there is a substantial theoretical-linguistic component to the papers. 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.

For more information about the PhD program requirements, visit http://web.mit.edu/linguistics/graduate/index.html.

**Bachelor of Science in Linguistics and Philosophy/Course 24-2**

### General Institute Requirements (GI Rs)

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement [three subjects can be satisfied by subjects in the Departmental Program (for the field of concentration)]</td>
<td>8</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total GIR Subjects Required for SB Degree**

17

### Communication Requirement

The program includes a Communication Requirement of 4 subjects:

- 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H);
- 2 subjects designated as Communication Intensive in the Major (CI-M).

### PLUS Departmental Program

Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

#### Required Subjects

- **24.906** Introduction to Linguistics, 12, HASS-S1, CI-H

#### Linguistics Track

- **24.901** Language and Its Structure I: Phonology, 12, HASS-S*
- **24.902** Language and Its Structure II: Syntax, 12, HASS-S, CI-M*
- **24.903** Language and Its Structure III: Semantics and Pragmatics, 12, HASS-S*
- **24.918** Workshop in Linguistic Research, 12, HASS-S, CI-M*

**One of the following three Linguistic Analysis subjects:**

- **24.909** Field Methods in Linguistics, 12, LAB, CI-M*
- **24.910** Advanced Topics in Linguistic Analysis, 12, HASS-S, CI-M*
- **24.914** Language Variation and Change, 12, HASS-S, CI-M*

**One of the following three Philosophy subjects:**

- **24.09** Minds and Machines, 12, HASS-HT, CI-H
- **24.241** Logic I, 12, HASS-H
- **24.251** Introduction to Philosophy of Language, 12, HASS-HT, CI-M*

**One of the following five Experimental Results subjects:**

- **24.904** Language Acquisition, 12, HASS-S*
- **24.905** Laboratory in Psycholinguistics, 12, LAB*
- **24.906** The Linguistic Study of Bilingualism, 12, HASS-S, CI-H*
- **24.907** Abnormal Language, 12,*, HASS-S
- **24.915** Linguistic Phonetics, 12, HASS-S*

### Philosophy Track

- **24.201** Topics in the History of Philosophy, 12, HASS-H, CI-M*
- **24.241** Logic I, 12, HASS-H
- **24.251** Introduction to the Philosophy of Language, 12, HASS-HT, CI-M*
- **24.260** Topics in Philosophy, 12, HASS-H, CI-M*

**One of the following two subjects:**

- **24.08** Philosophical Issues in Brain Science, 12, HASS-HT, CI-H
- **24.09** Minds and Machines, 12, HASS-HT, CI-H

**One of the following Knowledge and Reality subjects:**

- **24.111** Philosophy of Quantum Mechanics, 12, HASS-H
- **24.112** Space, Time, and Relativity, 12, HASS-H
- **24.114** A Philosophical History of Energy, 12, HASS-H
- **24.211** Theory of Knowledge, 12, HASS-H*
- **24.215** Topics in the Philosophy of Science, 12, HASS-H*
- **24.223** Metaphysics, 12, HASS-H*
- **24.253** Philosophy of Mathematics, 12, HASS-H*
- **24.280** Foundations of Probability, 12, HASS-H*

**One of the following three subjects:**

- **9.65** Cognitive Processes, 12, HASS-S*
- **24.904** Language Acquisition, 12, HASS-S*
- **24.905** Laboratory in Psycholinguistics, 12, LAB*

#### Restricted Electives

A coherent program of three additional subjects from linguistics, philosophy, or a related area.

**Units**

27–36

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**Doctor of Philosophy in Philosophy**

The program of studies leading to the doctorate in philosophy provides subjects and seminars in such traditional areas as logic, ethics, metaphysics, epistemology, philosophy of science, philosophy of language, philosophy of mind, aesthetics, social and political philosophy, and history of philosophy. Interest in philosophical problems arising from other disciplines, such as linguistics, psychology, mathematics, and physics, is also encouraged.

To enter the doctoral program, students must have done well in their previous academic work and must be formally accepted as candidates for the degree by the Department of Linguistics and Philosophy. Although there are no formal course requirements for admission, applicants must satisfy the committee on admissions that their preparation in philosophy and allied disciplines is sufficient for undertaking the study of philosophy at the graduate level.

Before beginning dissertation research, students are required to take two years of coursework, including a proseminar in contemporary philosophy that all students must complete in their first year of graduate study. Students are also required to demonstrate competence in the following areas: value theory, logic, and the history of philosophy.

Interdisciplinary study is encouraged, and candidates for the doctorate may take a minor in a field other than philosophy. Options for minors include psychology, linguistics, and logic.

Students who elect one of these options are expected to complete three approved graduate subjects in their minor field. There is no general
language requirement for the doctorate, except in those cases in which competence in one or more foreign languages is needed to carry on research for the dissertation.

For more information about the PhD program requirements, visit [http://web.mit.edu/philos/www/PhDprogram.html](http://web.mit.edu/philos/www/PhDprogram.html).

Inquiries
Information regarding undergraduate or graduate academic programs, research activities, admissions, financial aid, and assistantships may be obtained from the Department of Linguistics and Philosophy, Room 32-D808, 617-253-9372.

### FACULTY AND STAFF

**Faculty and Teaching Staff**
Richard Holton, PhD  
Professor of Philosophy  
Department Head  

David Pesetsky, PhD  
Ferrari P. Ward Professor of Linguistics  

MacVicar Faculty Fellow  
Linguistics Section Head

**Professors**
Alexander Byrne, PhD  
Professor of Philosophy  

Noam Chomsky, PhD  
Professor of Linguistics  

Kai von Fintel, PhD  
Professor of Linguistics  

Associate Dean, School of Humanities, Arts, and Social Sciences

Suzanne Flynn, PhD  
Professor of Second Language Acquisition  

Daniel Fox, PhD  
Professor of Linguistics  

(On leave)  

Edward A. Gibson, PhD  
Professor of Cognitive Science  

Sally Haslanger, PhD  
Professor of Philosophy  

Irene Heim, PhD  
Professor of Linguistics  

(On leave, fall)  

Sabine Iatridou, PhD  
Professor of Linguistics  

Michael Kenstowicz, PhD  
Professor of Linguistics  

Rae Langton, PhD  
Professor of Philosophy  

Vann McGee, PhD  
Professor of Philosophy  

Shigeru Miyagawa, PhD  
Kochi Prefecture-John Manjiro Professor of Japanese Language and Culture  

Professor of Linguistics  

Wayne O’Neil, PhD  
Professor of Linguistics  

Norvin Richards, PhD  
Professor of Linguistics  

MacVicar Faculty Fellow  

Irving Singer, PhD  
Professor of Philosophy  

(On leave)

**Associate Professors**
Adam Albright, PhD  
Associate Professor of Linguistics  

Michel DeGraff, PhD  
Associate Professor of Linguistics  

(On leave)  

Edward Flemming, PhD  
Associate Professor of Linguistics  

Martin Hackl, PhD  
Associate Professor of Linguistics  

Caspar Hare, PhD  
Associate Professor of Philosophy  

(On leave, spring)  

Agustín Rayo, PhD  
Associate Professor of Philosophy  

Bradford Skow, PhD  
Associate Professor of Philosophy  

(On leave)  

Roger White, PhD  
Associate Professor of Philosophy  

(On leave, spring)

**Assistant Professor**
Julia Markovits, PhD  
Assistant Professor of Philosophy

**Professors Emeriti**
Sylvain Bromberger, PhD  
Professor of Philosophy, Emeritus  

Morris Halle, PhD  
Institute Professor, Emeritus  

James Wesley Harris, PhD  
Professor of Spanish and Linguistics, Emeritus  

Samuel Jay Keyser, PhD  
Professor of Linguistics, Emeritus  

Judith Jarvis Thomson, PhD  
Professor of Philosophy, Emerita

Robert Stalnaker, PhD  
Laurance S. Rockefeller Professor of Philosophy  

Donca Steriade, PhD  
Class of 1941 Professor of Linguistics  

Kenneth N. Wexler, PhD  
Professor of Psychology and Linguistics  

Stephen Yablo, PhD  
Professor of Philosophy  

(On leave)
The Literature Section’s mission is to maintain a level of excellence and innovation consistent with the best universities while remaining responsive to MIT’s distinctive intellectual environment. The curriculum emphasizes interdisciplinary approaches to literary texts as well as theoretical, generic, and thematic subjects that range across geographical and historical boundaries.

The Literature Section accommodates students with a wide variety of interests and diverse career choices. The major provides a solid grounding in the discipline but remains flexible enough to allow students to explore the particular domains that most interest them. Students graduating from the MIT Literature program have in recent years been admitted into the best doctoral programs in the country and abroad. For those not pursuing literature as a career, the program nonetheless develops transferable skills in writing, comprehension, and analysis relevant to a variety of different professional paths—from journalism, law, and medical school to work in the gourmet food industry or computer game design.

Depending on the depth of one’s engagement, a student may major, minor, or concentrate in Literature. Regardless of the individual choice, our courses will introduce you to the pleasures of reading and interpretation, expose you to different ways of thinking about the world, and lead to a competence in writing and communication that will remain with you the rest of your life.

A supplement to this catalog is available before each semester, either online (http://lit.mit.edu/) or from Literature Headquarters, Room 14N-407. It offers detailed descriptions of all subjects being taught that term and includes specific information about subject content and required texts.

The Literature curriculum is arranged in four graduated categories:

- **Introductory subjects** (21L.000–21L.044) focus on major literary texts grouped in broad historical and generic sequences; all introductory subjects carry HASS and Communication Intensive credit.
- **Samplings** (21L.301–21L.315, 21L.345) are 6-unit subjects that provide both an alternative route into literary and filmic study and a less intensive means for students to sustain a commitment to reading and textual interpretation. Their focus is on critical exploration, comprehension, and group discussion, with less sustained attention to analytic writing skills. Students can combine most 6-unit Sampleings subjects to count as a HASS subject in the Humanities category and the equivalent of a subject in the Intermediate tier. However, no more than four 6-unit subjects may be combined in this manner. See http://web.mit.edu/hassreg/ and contact Literature Headquarters for details.
- **Intermediate subjects** (21L.420–21L.522) explore literary and visual forms as well as critical analysis in greater depth. Some subjects center on historical periods, literary themes, or genres; others focus on media studies, comparative cultural studies, or national literatures.
- **Seminar subjects** (21L.701–21L.715) are usually restricted to students who have taken at least two previous subjects in Literature and encourage a greater degree of independent work, such as oral reports and other special projects. Enrollment in seminars is strictly limited to a maximum of 12 students.

### Bachelor of Science in Literature/Course 21L

<table>
<thead>
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<tbody>
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<tr>
<td>Total Units Beyond the GIRs Required for SB Degree</td>
<td>180</td>
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</table>

**Notes**

For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.
The Literature Section also offers some advanced subjects in a foreign language (21L.616, 21L.638, and 21L.640) for students with adequate preparation. If appropriate, they may count toward the Literature major and minor requirements after consultation with the major/minor advisor.

In addition, the Literature Section often offers 6-unit special subjects for credit during IAP. Students may also choose to take special subjects (21L.592–21L.597) and independent study or research supervised by a faculty member (21L.900–21L.901) during the fall and spring terms.

Concentrations in Literature are available in particular genres (e.g., poetry, drama, fiction) and in historical periods (e.g., ancient studies, 19th-century literature, modern and contemporary literature), as well as in media and film studies, world literatures and cultures, popular culture, minority and ethnic studies, literary theory, and a range of national literatures.

Bachelor of Science in Literature/ Course 21L

The program in Literature leading to the degree of Bachelor of Science in Literature is equivalent to the curricula in English (or literary studies) of the major liberal arts universities. The Literature curriculum is notable also for its inclusion, along with traditional literary themes and texts, of materials drawn from film and media, popular culture, and minority and ethnic cultures.

Majors are required to take a minimum of 10 subjects, three of which must be seminars and no more than three of which may be introductory subjects. Students develop an appropriate course of study in consultation with a faculty advisor; majors choose from one of two areas in organizing four of their restricted electives (three for joint majors): historical periods or thematic complexes.

Minor in Literature

The minor aims to lay a foundation for advanced study and to enhance a student’s appreciation of major narrative, poetic, and dramatic texts in relation to the cultures that produced them.

The Minor in Literature consists of six subjects arranged into three levels of study as follows:

**Tier I**
- Introductory Level
- At least one and no more than two subjects from 21L.000–21L.044

**Tier II**
- Intermediate Level
- Two or three subjects from 21L.420–21L.522; Note: In most cases, two 6-unit Samplings subjects may be combined to substitute for an intermediate level subject.

**Tier III**
- Seminar Level
- At least two subjects from 21L.701–21L.715
- At least two subjects must focus primarily on material from before 1900.

Joint Degree Programs

Joint degree programs are offered in Literature in combination with a field in engineering or science (21E, 21S). See the joint degree programs listed under Humanities.

Subjects in Literature are described in the online MIT Subject Listing & Schedule, [http://student.mit.edu/catalog/index.cgi](http://student.mit.edu/catalog/index.cgi). Further information on subjects and programs may be obtained from Literature Headquarters, Room 14N-407, 617-253-3581, lit@mit.edu.

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Faculty and Teaching Staff

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Section Head

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Ford Foundation Professor in the Humanities

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Senior Lecturer

Wyn Kelley, PhD

Lecturers

Howard Eiland, PhD

Ina Lipkowitz, PhD

Professors Emeriti

Albert Ramsdell Gurney, Jr., MFA
Professor of Literature, Emeritus

Louis Kampf, BA
Professor of English, Emeritus

Irene Taylor, PhD
Professor of Literature, Emerita
MUSIC

The Music Program offers a broad range of opportunities to experience and explore the realm of music. A great variety of subjects is offered, ranging from Fundamentals of Music to Senior Seminar in Music. The subjects are arranged into six categories: introductory, history/literature, theory/composition, performance, special topics/advanced subjects, and music and media. Most students begin with introductory subjects, but anyone with musical training is encouraged to begin with history/literature or theory/composition subjects, which constitute the nucleus of the program. Graduate credit is available for upper-level performance, special topics/advanced, and music and media subjects.

The symphony orchestra, choral groups, wind and jazz ensembles, chamber music groups, and the Senegalese drumming and Balinese Gamelan ensembles are an integral part of MIT’s cultural life, and any student is welcome to audition for one or more of them. Auditions are held at the beginning of each term. Academic credit is available for performance groups and for some private study.

Twenty-three professors and lecturers who specialize in composition, performance, and music history offer our wide variety of subjects.

Bachelor of Science in Music/Course 21M

The undergraduate program leading to the degree of Bachelor of Science in Music represents a confluence of three basic areas: a thorough grounding in the theory underpinning Western music, a comprehensive study of the history and repertoire of Western and World music, and performing experience in small and/or large ensembles. Seven required subjects (one of which consists of two terms of performance) and three restricted electives constitute the core of the program, which should be supplemented by additional electives. This program is analogous to that for music majors at leading liberal arts colleges and universities, and it prepares a student in many ways for graduate study in the field. Before declaring their major, students should demonstrate proficiency in instrumental or vocal performance by participating in a performance subject, and in harmony/counterpoint by obtaining a grade of B or better in 21M.301.

Minor in Music

The Minor in Music requires six subjects that will give students experience within the three main branches of music: performance, composition, and history. The four subjects in Tiers I and II are at the introductory or intermediate level. The two in Tier III will provide depth in one of the three branches.

Tier I One subject, typically chosen from the following:
21M.011 Introduction to Western Music
21M.030 Introduction to World Music
21M.051 Fundamentals of Music

Students with sufficient musical knowledge or experience may substitute a subject from Tier II or III for the subject in Tier I. Please discuss this possibility with the minor advisor.

Tier II Three subjects:
Theory/Composition: 21M.301 and one from each of the following areas:
History/Literature: 21M.220, 21M.235, 21M.250, 21M.260, 21M.291, 21M.293, or another subject (with approval of minor advisor)
Performance (two terms): 21M.401-499

Tier III Two subjects from one of the following areas of specialization:
History/Literature: 21M.201–299, 21M.500
Theory/Composition: 21M.302–399
Performance (four terms): 21M.401–499

Joint Degree Programs

For students interested in combining the study of engineering or science with music, a joint major in the 21E or 21S degree program provides an opportunity to study two realms. The joint major requires four subjects (21M.301, 21M.302, 21M.500, and one of the following: 21M.220, 21M.235, 21M.250, or 21M.260), two terms of performance subjects, electives in two categories (usually theory/composition, history/literature), a third elective in any category (theory/composition, history/literature, or two terms of performance), and six subjects that fulfill the engineering or science curriculum portion of the joint degree.

NB: Joint as well as full majors may, with faculty approval, substitute three full years of Advanced Music Performance (21M.480) and a senior recital for the two required terms of performance subjects and two of the three electives.

Students wishing to enroll in any of these degree programs should consult the major or minor advisor in music no later than the first term of their junior year.

Subjects in music are described in the online MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi. Further information on subjects and programs may be obtained from the Music Section Office, Room 4-246, 617-253-3210.

THEATER ARTS

The Program in Theater Arts offers the opportunity for an imaginative and rigorous engagement with the arts and disciplines of theater: acting, directing, playwriting, design, technical work, dance, and scholarship. The program combines work in the classroom, in the studio, and on the stage. Performance is the testing ground for what is learned in the classroom and the experiences, from student-generated workshops to fully-mounted productions by Theater Arts, Dramashop, and Playwrights-in-Performance. All these activities are guided by a professional faculty and staff, often with the enriching participation of guest artists. A degree is offered under Course 21; see the Department of Humanities section for details.

Minor in Theater Arts

The Minor in Theater Arts is designed to give students the opportunity to experiment in the making of theater. The flexibility of the minor allows students either to explore the basic principles of several theater disciplines or to concentrate more deeply on one.
Bachelor of Science in Music/Course 21M

General Institute Requirements (GIRs) Subjects  
Science Requirement 6  
Humanities, Arts, and Social Sciences Requirement [three subjects can be from the Departmental Program] 8  
Restricted Electives in Science and Technology (REST) Requirement 2  
Laboratory Requirement 1  
Total GIR Subjects Required for SB Degree 17

Communication Requirement
The program includes a Communication Requirement of 4 subjects:  
2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and  
2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

Required Subjects 84
21M.220 Early Music, 12, HASS-A; 21M.301*  
or 21M.260 Stravinsky to the Present, 12, HASS-A; 21M.301*  
21M.255 Monteverdi to Mozart: 1600-1800, 12, HASS-A, Ci-M; 21M.301*  
or 21M.250 Beethoven to Mahler: 1800-1910, 12, HASS-A; 21M.301*  
21M.301 Harmony and Counterpoint I, 12, HASS-A; 21M.051*  
21M.302 Harmony and Counterpoint II, 12, HASS-A; 21M.301  
21M.303 Writing in Tonal Forms I, 12, HASS-A; 21M.302  
or 21M.359 Studies in Musical Composition, 12, HASS-A; 21M.302*  
Two terms of Performance subjects, 21M.401–21M.499 (6 units each)  
21M.500 Senior Seminar in Music, 12, HASS-A, Ci-M; 21M.302, two 21M.2xx subjects

Restricted Electives
One 12-unit subject in theory/composition (21M.300–21M.399)  
And one of the following:  
One additional 12-unit subject in theory/composition (21M.300s)  
One 12-unit subject in history/literature (21M.200s)  
Two terms of performance (21M.400s, 6 units each), to be chosen with permission of the major advisor and in consultation with the ensemble director, typically from subjects emphasizing individual performance.  
Full majors may, with faculty approval, substitute three full years of 21M.480 Advanced Musical Performance and a senior recital for the two required terms of performance subjects and two of the four electives.

Departmental Program Units That Also Satisfy the GIRs
(36)

Unrestricted Electives 96

Total Units Beyond the GIRs Required for SB Degree 180

Notes
* Alternate prerequisites and corequisites are listed in the subject description.  
† Students who entered prior to fall 2010 may use this subject to satisfy the HASS-D requirement.

For an explanation of credit units, or hours, please refer to the online help in the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi. For further information on subjects and programs, contact the Music and Theater Arts Office, Room 4-246, 617-253-3210.
FA C U L T Y  A N D  S T A F F

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Section Head

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Professor of Music
MacVicar Faculty Fellow
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Institute Professor
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Karen Perlow, BA
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Faculty Emeriti
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Stephen Erdely
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Ellen T. Harris, PhD
Class of 1949 Professor of Music, Emerita
Michael Ouellette, MFA
Senior Lecturer in Theater Arts, Emeritus
Barry Lloyd Vercoe, DMA
Professor of Media Arts and Sciences, Emeritus
Political science is concerned with the systematic study of government and the political process. Within the discipline, scholars analyze the development, distribution, and uses of political power; determinants and consequences of various forms of political behavior and sources of political conflict; ways in which conflicts are both intensified and resolved; and the relationship between the individual and the state. Political science is a discipline of special interest to scientists and engineers who must understand the political system within which they live in order to evaluate its influence upon that system. It is of interest as well to those students who are considering careers in public service or university teaching and research.

The Department of Political Science has a research-oriented faculty that welcomes both undergraduate and graduate students in ongoing research. The department covers the fields of American politics and public policy, comparative politics, international relations and foreign policy, and political philosophy and social theory, with particular emphasis on ethnicity and identity, international security, representation, and the politics of globalization. The Department of Political Science offers degree programs at the bachelor’s, master’s, and doctoral levels.

UNDERGRADUATE STUDY

Bachelor of Science in Political Science/ Course 17

The political science curriculum for undergraduates combines professional social science training with opportunities for a broad liberal arts education. Students may choose subjects from a wide range of both undergraduate and graduate offerings, and are encouraged to engage in independent research projects. In addition, the department sponsors an internship program in which students work in governmental agencies, legislative offices, community associations, international organizations, and advocacy groups at all levels.

The undergraduate program prepares students for study in political science, law, public policy, and related fields, and for careers in government, business, law, research, teaching, or journalism. This program is also designed to give students, whatever their career objectives, an understanding of political institutions and processes. Some students want to focus on political systems themselves; others choose to concentrate on the political aspects of public policy, focusing on such issues as the environment, health, or arms control. Both of these perspectives are found in the program.

Subjects are offered by the department in the following fields: political theory, political economy, American politics, public policy, international relations and security studies, comparative politics, and models and methods. Students may work out individualized programs with the assistance of a faculty advisor.

In the junior year students are introduced to the major theoretical and methodological themes of political science in two subjects:

17.869 Political Science Scope and Methods (typically fall term, junior year) and
17.871 Political Science Laboratory (typically spring term, junior year)

The department believes that every political science major should have the experience of conducting and writing at least one substantial research project, a requirement that is fulfilled by the senior thesis. Each undergraduate chooses a thesis advisor and a second thesis reader in his or her area of interest. The student then registers for:

17.ThT Thesis Research Design Seminar (fall term, senior year) and
17.ThU Thesis (spring term, senior year)

In addition to the thesis, there are numerous other opportunities for students to pursue research interests. Students are eligible to receive academic credit or limited funding for expenses or wages through the Institute-wide Undergraduate Research Opportunities Program. Students should consult the department’s UROP coordinator to discuss specific projects.

Minor in Political Science

The objective of the Minor in Political Science is to deepen and expand student knowledge of the discipline of political science. A minor in political science consists of six subjects divided into two tiers, selected from any of the discipline’s subfields as listed in the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.

Tier I consists of introductory classes, and Tier II, of upper-level classes.

The requirements of the minor are as follows:

Tier I

At least one but no more than two introductory classes (introductory classes are designated with two-digit numbers). These introductory classes provide broad theoretical and/or empirical overviews of their subject matter. Examples include:

17.01J Justice
17.20 Introduction to the American Political Process
17.40 American Foreign Policy: Past, Present, and Future
17.50 Introduction to Comparative Politics

Tier II

At least four but no more than five upper-level classes (upper-level classes are designated with three-digit numbers). These specialized classes provide students with advanced and in-depth examination of their subject matter. Examples include:

17.195 Globalization
17.405 Seminar on Politics and Conflict in the Middle East
17.477J Technology and Policy of Weapons Systems
17.811 Game Theory and Political Theory

For a listing of available subjects in these areas, consult Tobie Weiner in the Political Science Undergraduate Office, Room E53-484 or the SHASS Dean’s Office, Room 4-240.

Minor in Applied International Studies

The interdisciplinary HASS Minor in Applied International Studies prepares students for an increasingly global business and research environment by integrating international learning into their course of study. A detailed description of this minor may be found under Interdisciplinary Undergraduate Programs and Minors in Part 3.

Minor in Public Policy

The Department of Political Science jointly offers a Minor in Public Policy with the Department of Urban Studies and Planning (Course 11). A detailed description and list of requirements for this minor may be found under Interdisciplinary Undergraduate Programs and Minors in Part 3.
Bachelor of Science in Political Science/Course 17

General Institute Requirements (GIRs)                      Subjects
Science Requirement                                           6
Humanities, Arts, and Social Sciences Requirement [three subjects can be satisfied by subjects in the Departmental Program] 8
Restricted Electives in Science and Technology (REST) Requirement 2
Laboratory Requirement                                         1
Total GIR Subjects Required for SB Degree                    17

Communication Requirement
The program includes a Communication Requirement of 4 subjects:
2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H), and
2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program                      Units
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

Required Subjects
17.869 Political Science Scope and Methods, 12, HASS, CI-M
17.871 Political Science Laboratory, 15, LAB; 17.869*, 17.871, or permission of instructor
17.ThT Thesis Research Design Seminar, 12, CI-M; 17.869 , 17.871, or permission of instructor
17.ThU Undergraduate Political Science Thesis (at least 12 units; additional units by special arrangement)

Restricted Electives
Normally seven subjects divided as follows:
political philosophy/social theory: one political science subject in the field of political philosophy/social theory (17.00–17.099)
American politics: one political science subject in the field of American politics (17.20–17.299)
Public policy: one political science subject in the field of public policy (17.30–17.399), or a subject in another field designated as fulfilling the public policy requirement
International politics: one political science subject in the fields of international relations/security studies (17.40–17.499) or comparative politics (17.50–17.599)
Plus three additional political science subjects representing a coherent plan of study. Specific subjects satisfying these criteria should be chosen in consultation with a faculty advisor.

Departmental Program Units That Also Satisfy the GIRs
(30–36)

Unrestricted Electives
(81–99)

Total Units Beyond the GIRs Required for SB Degree
180

No subject can be counted both as part of the 17-subject GIRs and as part of the 180 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

Notes
* Alternate prerequisites are listed in the subject description.
** Students typically enroll in subjects as follows: 17.869, fall term, junior year; 17.871, spring term, junior year; 17.ThT, fall term, senior year; 17.ThU, spring term, senior year.

For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.

GRADUATE STUDY

The Department of Political Science offers programs leading to the Master of Science in Political Science and the Doctor of Philosophy.

Entrance Requirements for Graduate Study
All applicants must take the GRE general test. Non-native English speakers must take the Test of English as a Foreign Language (TOEFL) or International English Language Testing System (IELTS). Applicants from all disciplines are welcome. Applicants need not have majored in political science, though some prior coursework in political science or related subjects, such as history, economics, philosophy, psychology, or sociology is helpful.

Master of Science in Political Science
The Master of Science in Political Science is a one-year program intended for students who wish to develop skills in applied research in preparation for a career in public policy or with a business or research organization. The master’s program emphasizes intensive preparation in a single field of study. Applicants to the SM program should specify their field of specialization.

The minimum number of subjects required for the SM degree is six graduate subjects, at least four of which must be completed in the Political Science Department at MIT. The remaining two may be taken elsewhere at MIT or through cross-registration at Harvard University. A 3.5 GPA must be maintained. A master’s thesis is required. See the section on Graduate Education in Part 1 for the general requirements for the SM.

Accelerated Master of Science in Political Science
The department offers a five-year program leading to the Bachelor of Science and Master of Science, awarded simultaneously. This program is open to MIT undergraduate Political Science majors only. It allows the student to plan for a single combined SB-SM thesis written during the last three terms at the Institute. Undergraduate Institute requirements may be completed during the fifth year of the program.

Doctor of Philosophy
Doctoral students must complete the following requirements:
A one-term seminar for first-year students covering fundamental ideas, theories, and methods in modern political science
• One class in statistics
• One class in empirical research methods
• One class in political philosophy
• Reading proficiency in one language other than English (demonstrated by two semesters of intermediate-level college course work or an exam) or knowledge of advanced statistics (demonstrated by three semesters of course work or an exam)
• A second-year paper and related workshop
• A doctoral thesis

In addition, doctoral students are required to elect two of the following major fields: American politics and public policy, comparative politics, international relations, models and methods, political economy, political philosophy and social theory, and security studies. In each of the two elected fields students will take a written general exam followed by a single oral exam covering both fields. Specific fields may have additional requirements.

Students may take subjects in other MIT departments. Cross-registration arrangements also permit enrollment in subjects taught in the Graduate School of Arts and Sciences at Harvard University and in some of Harvard’s other graduate schools. Students are encouraged to do field research and develop close working ties with faculty members engaged in major research activities.

Inquiries
Additional information regarding graduate programs in the department and admissions may be obtained from the graduate administrator, Susan Twarog, 617-253-8336. Written inquiries should be addressed to Department of Political Science, Room E53-467.

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Adam Berinsky, PhD
Professor of Political Science
Andrea Campbell, PhD
Professor of Political Science
(On sabbatical)
Nazli Choucri, PhD
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Associate Professor of Political Science
Lily Tsai, PhD
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(On sabbatical)

Associate Professors
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Associate Professor of Political Science
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Professors Emeriti
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Lincoln P. Bloomfield, PhD
Professor of Political Science, Emeritus
Joshua Cohen, PhD
Professor of Political Science, Emeritus
Willard R. Johnson, PhD
Professor of Political Science, Emeritus
Michael Joseph Piore, PhD
Professor of Political Science, Emeritus
George W. Rathjens, PhD
Professor of Political Science, Emeritus
Harvey M. Sapolsky, PhD
Professor of Political Science, Emeritus
Eugene B. Skolnikoff, PhD
Professor of Political Science, Emeritus
The Program in Science, Technology, and Society (STS) focuses on the ways in which scientific, technological, and social factors interact to shape modern life. The program brings together humanists, social scientists, engineers, and natural scientists, all committed to transcending the boundaries of their disciplines in a joint search for new insights and new ways of reaching science and engineering students. The goal of the program is to set up a forum to explore the relationship between what scientists and engineers do and the constraints, needs, and responses of society.

Located in a major university where most people study science and engineering, STS is dedicated to understanding the context of science and engineering.

UNDERGRADUATE STUDY

MIT students are increasingly seeking to understand the social and historical contexts in which they will work and the social consequences of what they will do in their professional careers. STS subjects help them think realistically and creatively about the intellectual, moral, political, and social issues raised by the rapid growth of science and technology in the 20th century and beyond.

STS contributes to undergraduate education at MIT in several ways. It offers general subjects to introduce students to broad social and intellectual perspectives on science and engineering fields. It also offers more specialized subjects in the history of science and technology and in social and cultural studies of science and technology. Within each of these categories, students can choose both introductory and more advanced subjects.

The HASS concentration in STS requires three STS subjects, at least one and not more than two of which must be selected from the following list of Tier I subjects.

Minor in Science, Technology, and Society

The goal of the minor program is to give students a broad social perspective on the fields of engineering and science: how they have evolved and how they fit into the wider context of society, culture, politics, and values.

The Minor in Science, Technology, and Society consists of six STS subjects, including STS.091 Critical Issues in STS, at least one subject from the Tier I list, and at least one subject from the Tier II list.

Tier I

STS.001 Technology in American History
STS.003 The Rise of Modern Science
STS.005 Disease and Society in America
STS.006J Bioethics
STS.007 Technology in History
STS.008 Technology and Experience
STS.009 Evolution and Society
STS.010 Neuroscience and Society
STS.011 Ethics and Politics in Science and Technology

Tier II

All other STS subjects (see http://web.mit.edu/sts/academic/tier2.html)

Double Major

For students who wish to integrate their professional study of engineering or science with a rigorous treatment of its relation to social and historical forces, STS offers a double major in cooperation with the Schools of Engineering and Science. The object of this program is to give those students the full technical and scientific education provided by a science or engineering major, balanced with intensive study of the historical and social contexts of science and technology. Double major applications from students in other Schools (e.g., Architecture and Planning; Management; Humanities, Arts, and Social Sciences) will be considered on a case-by-case basis.

Students in the double major program must complete all the requirements of their majors as well as the STS requirements described below. In addition, they must write an STS thesis. If the second major also requires a thesis, students may coordinate their thesis effort pending approval of undergraduate officers in both majors.

The STS requirements include 14 subjects as follows: at least one STS Tier I subject; at least one Tier II subject; five other STS subjects; STS.091 Critical Issues in STS; pre-thesis tutorial; the thesis; and four subjects related to the historical and social study of science and technology. Further details on the requirements of this double major may be obtained from the STS undergraduate academic officer and the STS academic administrator.

Joint Degree Programs

Students who wish to integrate studies in STS and science or engineering in the context of a single degree should consider this program. It leads to one degree, either a Bachelor of Science in Humanities and Science or a Bachelor of Science in Humanities and Engineering.

Students who take this degree must complete eight STS subjects (including at least one STS Tier I subject, at least one STS Tier II subject, and STS.091 Critical Issues in STS), plus a pre-thesis tutorial and a thesis.

Consult the 21E/21S degree chart for details on the requirements for this joint degree. Further details may be obtained from the SHASS Dean’s Office, Room 4-240, hass-www@mit.edu, and the STS academic administrator.

GRADUATE STUDY

In collaboration, STS, the History Faculty, and the Anthropology Program offer a Program in History, Anthropology, and Science, Technology and Society (HASTS) leading to the PhD.

The objective of the program is to develop advanced competence in the study of science and technology from a historical and social scientific perspective. Students are expected to develop professional mastery of a field of history or one of the social sciences. They must also master the underlying concepts in science and engineering that relate to their special field of interest.

Graduate students are required to take at least 10 subjects and usually complete them within their first two years. Normally, all students take the required introductory seminars, 21H.991, 21A.859 and STS.260, in their first year. Students are encouraged to take 21A.809 at some point in their program. To fulfill the remaining subject requirement, students choose from among several departmental seminars designed to offer more in-depth study of particular topics. They may also take subjects offered by other MIT departments and through cross-registration with Harvard.
Bachelor of Science in Science, Technology, and Society/Double Major/Course STS(I)

<table>
<thead>
<tr>
<th>General Institute Requirements (GIRs)</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement (three subjects can be satisfied by subjects in the Departmental Program)</td>
<td>8</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>1</td>
</tr>
<tr>
<td>Total GIR Subjects Required for SB Degree</td>
<td>17</td>
</tr>
</tbody>
</table>

Communication Requirement
The program includes a Communication Requirement of 4 subjects:
- 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and
- 2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

<table>
<thead>
<tr>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>One STS Tier I subject</td>
<td>51–54</td>
</tr>
<tr>
<td>One STS Tier II subject</td>
<td></td>
</tr>
<tr>
<td>STS.091 Critical Issues in STS, 12, HASS-E, CI-M *</td>
<td></td>
</tr>
<tr>
<td>STS.ThT Undergraduate Thesis Tutorial, 6</td>
<td></td>
</tr>
<tr>
<td>STS.ThU Undergraduate Thesis, 12, CI-M *</td>
<td></td>
</tr>
</tbody>
</table>

Restricted Electives
A coherent group of five elective subjects in STS, plus four subjects related to the historical and social study of science and technology (three of which can be satisfied by HASS GIRs), in consultation with the STS undergraduate officer.

<table>
<thead>
<tr>
<th>Departmental Program Units That Also Satisfy the GIRs</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>(27–36)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unrestricted Electives</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>(4–66)</td>
<td></td>
</tr>
</tbody>
</table>

Total Units Beyond the GIRs Required for SB Degree
180

No subject can be counted both as part of the 17-subject GIRs and as part of the 180 units required beyond the GIRs. Every subject in the student's departmental program will count toward one or the other, but not both.

Notes
*Prerequisites and corequisites are listed in the subject description.

The full major in Science, Technology, and Society (STS) may be pursued only as a second major program in conjunction with another degree program in a field of engineering or science, or in other fields on a case-by-case basis.

For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, web.mit.edu/catalog/index.cgi.

Upon the satisfactory completion of general examinations in the third year, students proceed to the writing of a dissertation proposal and dissertation, usually with the assistance of a multidisciplinary advisory committee.

Students from any academic discipline are invited to apply to the doctoral program.

For additional information about the graduate program, visit the HASTS website at http://web.mit.edu/hasts/, or contact the STS academic administrator, Room E51-163, 617-253-9759.

Inquiries
Additional information on the Program in Science, Technology, and Society may be obtained from the STS academic administrator, Room E51-163, 617-253-9759, http://web.mit.edu/sts/.

FACULTY AND STAFF

Faculty and Teaching Staff
David Kaiser, PhD
Germeshausen Professor of the History of Science
Senior Lecturer, Department of Physics
MacVicar Faculty Fellow
Program Director

Professors
Michael M. J. Fischer, PhD
Andrew W. Mellon Professor in the Humanities
Deborah Fitzgerald, PhD
Professor of the History of Technology
Dean, School of Humanities, Arts, and Social Sciences
Kenneth Rogers Manning, PhD
Thomas Meloy Professor of Rhetoric and the History of Science

David A. Mindell, PhD
Frances and David Dibner Professor of the History of Engineering and Manufacturing
Professor of Aeronautics and Astronautics

Theodore A. Postol, PhD
Leverett Howell and William King Cutten Professor of the History of Technology
Sherry Turkle, PhD
Abby Rockefeller Mauzé Professor of the Social Studies of Science and Technology

Rosalind H. Williams, PhD
Bern Dibner Professor of the History of Science and Technology

Associate Professors
Natasha Schüll, PhD
Associate Professor of Science, Technology, and Society

Hanna Rose Shell, PhD
Leo Marx Career Development Associate
Professor of Science, Technology, and Society
Assistant Professor
Clapperton Mavhunga, PhD
Assistant Professor of Science, Technology, and Society

Adjunct Professor
John Durant, PhD
Adjunct Professor of Science, Technology, and Society

Senior Lecturer
Leo Marx, PhD
William R. Kenan Professor of American Cultural History, Emeritus

Professors Emeriti
Louis Lawrence Bucciarelli, PhD
Professor of Engineering and Technology Studies, Emeritus

Loren R. Graham, PhD
Professor of the History of Science, Emeritus

Evelyn Fox Keller, PhD
Professor of History and Philosophy of Science, Emerita

Kenneth Keniston, PhD
Andrew W. Mellon Professor of Human Development, Emeritus

Leo Marx, PhD
William R. Kenan Professor of American Cultural History, Emeritus

Eugene B. Skolnikoff, PhD
Professor of Political Science, Emeritus

Leon Trilling, PhD
Professor of Aeronautics and Astronautics, Emeritus
The Program in Writing and Humanistic Studies teaches students the craft, forms, and traditions of contemporary writing and communication. Some students explore writing as a means of artistic expression. Some learn how to communicate the results of their science and technical work to broad audiences and members of their professions. Others work collaboratively within the evolving framework of digital media to become skilled in interactive and nonlinear forms of communication. All subjects in the program emphasize the development of the foundational skills, creative initiative, and critical sensibility necessary to become a good writer.

Subjects in the program’s three options—creative writing (fiction, nonfiction prose, poetry), science writing, or digital media—are taught at both introductory and advanced levels. All subjects require extensive writing and revision. Student work is typically discussed in workshops and receives the written commentary of the instructor.

Concentrations in writing establish a course of study in fiction, prose nonfiction (including rhetoric), science writing, or digital media, and offer engineering or science majors an opportunity to develop abilities that will play a key role in their professional careers.

The Minor in Writing and Humanistic Studies offers students a sustained opportunity to work in one of the program’s three options while also exploring offerings in the program’s core curriculum.

The program also offers a one-year master’s degree (SM) in science writing. Students in the graduate program receive intensive training in the craft of turning technically complex ideas and discoveries into compelling writing and productions for broad audiences. Approaches in the graduate curriculum range from daily journalism to long-form prose, documentary audio and video, and digital media; students complete a required internship.

Bachelor of Science in Writing

The Program in Writing and Humanistic Studies offers three undergraduate options leading to the Bachelor of Science in Writing. The curriculum in creative writing is designed to develop expertise in writing and reading a genre of the student’s choice (e.g., fiction, poetry, or nonfiction prose forms), familiarity with related genres, and a three-subject focused exposure to an allied discipline, usually in the humanities, arts, or social sciences. This curriculum offers students flexibility in designing their courses of study for both breadth and depth.

The curriculum in science writing is designed to enable the student to develop mastery of the craft and rhetoric of writing about the worlds of science and engineering for broad audiences. This writing major is an option for students interested in science journalism, longer forms like the science documentary, and communication issues related to the public understanding of science and technology. It is also designed to work as a complementary major for students majoring in science, engineering, or another field of study at MIT. This major includes a three-subject exposure to an allied field such as science, technology, and society; political science; or comparative media studies. Students also fulfill an internship requirement, which provides in-depth practical experience.

The digital media major offers in-depth study of emerging interactive and nonlinear styles of narrative, as well as individual and collaborative experience in producing digitally mediated forms, both aesthetic and utilitarian. Students gain extensive experience in using a variety of authoring systems to develop large-scale websites, web-based hypertext products, computer games, interactive fiction and poetry, and digitally mediated visual worlds. Knowledge of programming is often helpful, but not necessary.

Minor in Writing

The Minor in Writing consists of six subjects focusing on one of the three areas mentioned above, arranged into two tiers of study as follows:

Tier I

<table>
<thead>
<tr>
<th>Subject</th>
<th>Credits</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>21W.011–21W.013</td>
<td>3</td>
<td>Writing and Rhetoric</td>
</tr>
<tr>
<td>21W.021–21W.024</td>
<td>3</td>
<td>Writing and Experience</td>
</tr>
<tr>
<td>21W.031–21W.035</td>
<td>3</td>
<td>Science Writing and New Media</td>
</tr>
<tr>
<td>21W.041J</td>
<td>1.5</td>
<td>Writing about Literature</td>
</tr>
<tr>
<td>21W.042J</td>
<td>1.5</td>
<td>Writing with Shakespeare</td>
</tr>
<tr>
<td>21W.755</td>
<td>3</td>
<td>Writing and Reading Short Stories</td>
</tr>
<tr>
<td>21W.756</td>
<td>3</td>
<td>Writing and Reading Poems</td>
</tr>
</tbody>
</table>

Tier II

Five subjects from among the remaining writing subjects

Joint Degree Programs

Joint degree programs are offered in writing in combination with a field in engineering or science (the 21E and 21S degrees). See the joint degree programs listed under Humanities.

Graduate Program in Science Writing

The one-year Graduate Program in Science Writing is aimed at students who wish to write about science and technology for general readers, in ordinary newsstand magazines and newspapers, in popular and semi-popular books, on the walls of museums, or on television or radio programs. Students may be graduates of undergraduate science, engineering, journalism or writing programs; experienced journalists and freelance writers; working scientists or engineers; historians of science and technology; or other scholars, including those already holding advanced degrees.

The program is built around an intensive year-long advanced science writing seminar. In addition, students choose one elective each semester, write a substantial thesis, and complete an internship.

The graduate program maintains links to MIT’s Program in Science, Technology, and Society; to the Comparative Media Studies program; and to the Knight Science Journalism Fellowships program. For more information, see the descriptions of the Science, Technology, and Society and Comparative Media Studies programs in Part 2. See Interdisciplinary Research and Study in Part 3 for more information about the Knight Science Journalism Fellowships program.

Writing and Communication Center

The MIT Writing and Communication Center offers free individual writing consultation on an appointment or drop-in basis to all members of the MIT community. In addition, the center gives mini-sessions each term on a variety of writing topics, and also offers workshops for people for whom English is a second language. For further information, contact the Writing Center at 617-253-3090.
Bachelor of Science in Writing/Course 21W

<table>
<thead>
<tr>
<th>General Institute Requirements (GIRs)</th>
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<th>Units</th>
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</thead>
<tbody>
<tr>
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<td></td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total GIR Subjects Required for SB Degree</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

**Communication Requirement**
The program includes a Communication Requirement of 4 subjects:
- 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and
- 2 subjects designated as Communication Intensive in the Major (CI-M).

**PLUS Departmental Program**
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

### Option 1: Creative Writing (fiction, nonfiction, poetry)

**Required Subjects**
- 21W.ThT Writing and Humanistic Studies Pre-Thesis Tutorial, 6
- 21W.ThU Writing and Humanistic Studies Thesis, 12, CI-M; 21W.ThT

**Restricted Electives**
Six subjects centered on creative writing, of which one is normally introductory; three subjects in literature, one of which may be in CMS.

### Option 2: Science Writing

**Required Subjects**
- 21W.777 The Science Essay, 12, HASS-H, CI-M
- 21W.778 Science Journalism, 12, HASS-H, CI-H
- 21W.779 Science Writing Internship, 12, HASS-H
- 21W.ThT Writing and Humanistic Studies Pre-Thesis Tutorial, 6
- 21W.ThU Writing and Humanistic Studies Thesis, 12, CI-M; 21W.ThT

**Restricted Electives**
Four subjects in writing, of which one is normally introductory; three are writing subjects approved for this major, one of which is in digital media (9 units).

### Option 3: Digital Media

**Required Subjects**
- 21W.766 The Word Made Digital, 12, HASS-A
- 21W.767 Interactive and Non-Linear Narrative: Theory and Practice, 12, HASS-A
- 21W.768 Communicating with Web-Based Media, 12, HASS-A, CI-H
- 21W.ThT Writing and Humanistic Studies Pre-Thesis Tutorial, 6
- 21W.ThU Writing and Humanistic Studies Thesis, 12, CI-M; 21W.ThT

**Restricted Electives**
Three subjects in writing, which may be in digital media, creative writing, or science writing, and three related subjects from another department.

**Total Units Beyond the GIRs Required for SB Degree**

No subject can be counted both as part of the 17-subject GIRs and as part of the 180 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

**Notes**
For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, [http://student.mit.edu/catalog/index.cgi](http://student.mit.edu/catalog/index.cgi).
Associate Professors
Ta-Nehisi Coates
Visiting Associate Professor
Martin Luther King Jr. Fellow
Douglas A. (Fox) Harrell, Jr., PhD
Associate Professor of Digital Media
Helen Elaine Lee, JD
Associate Professor of Writing
Nick Montfort, PhD
Associate Professor of Digital Media

Assistant Professors
Vivek Bald, PhD
Assistant Professor of Writing and Digital Media
Sasha Costanza-Chock, PhD
Assistant Professor of Civic Media
Seth Mnookin, BA
Assistant Professor of Science Writing

Adjunct Professor
Joe Haldeman, MFA
Adjunct Professor of Fiction

Senior Lecturer
Edward Barrett, PhD
Senior Lecturer in Writing

Lecturers
Atissa Banuazizi, MA
Karen Boiko, PhD
Harlan Breindel, MA
Stephen Brophy, BA
Mary Caulfield, MA
B. D. Colen, BA
Jane Abbott Connor, MA
William Corbett, BA
Jennifer Craig, MA
David Custer, BA
Kathleen Delaney, PhD
Nora Delaney, MA
Thomas Delaney, MA
Rebecca Faery, PhD
Elizabeth Fox, PhD
Erica Funkhouser, MA
JoAnn Graziano
Gay Haldeman, MA
Elizabeth Harris, MA
Louise Harrison-Lepera, MA
Diane Hendrix, MA
Robert Irwin, PhD
Nora Jackson, MA
Sonal Jhaveri, PhD
Suzanne Lane, PhD
Acting Director, Writing Across the Curriculum
Marilyn Levine, MA
Shariann Lewitt, MFA
Lucy Marx, MA
Janis Melvold, PhD
Marilee Ogren, PhD
Karen Pepper, PhD
Kym Ragusa, MFA
Leslie Ann Sulit Roldan, PhD
Thalia Rubio, MEd
Susan Ruff, BA
Juergen Schoenstein, MA
Pamela Siska, MA
Amanda Sobel, MA
Susan Spilecki, MA
Jessie Stickgold-Sarah, PhD
Cynthia Taft, PhD
Donald Unger, PhD
Kim Vaeth, MA
Lydia Volaitis, PhD
Andrea Walsh, PhD
Jeanne Wildman, JD

Research Staff
Postdoctoral Fellow
Gretchen Henderson, PhD

Professors Emeriti
Anita Desai, BA
John E. Burchard Professor of Humanities, Emerita
Robert Kanigel, BS
Professor of Science Writing, Emeritus
James H. Williams, Jr., PhD
SEPTE Professor of Engineering, Emeritus
Cynthia Griffin Wolff, PhD
Class of 1922 Professor of Literature, Emerita
The MIT Sloan School of Management, like the rest of MIT, catalyzes innovation through research and education. As one of the world’s leading business schools, MIT Sloan seeks to develop principled, innovative leaders who improve the world. Sloan graduates are particularly good at building cutting-edge products, services, markets, and organizations—delivering the advances essential for competitive survival and for economic and social progress.
The mission of the MIT Sloan School of Management is to develop principle, innovative leaders who improve the world and to generate ideas that advance management practice.

To accomplish this, the School

• Offers premier programs for shaping leaders who will create, redefine, and build cutting-edge products, services, markets, and organizations
• Collaborates across MIT to capitalize on and contribute to the Institute’s distinctive intellectual excellence and entrepreneurial culture
• Attracts, develops, and retains outstanding faculty and staff who lead the world in management education and research
• Enrolls students with integrity, strong leadership potential, high aspirations, and exceptional intellectual ability
• Fosters a cooperative and adventurous learning community that includes alumni and business partners, works on important problems, and is based on mutual respect, rigorous analysis, and high ethical standards

History
The MIT Sloan School grew out of a curriculum in engineering administration—Course 15—that was first offered to MIT undergraduates in 1914. A program leading to a master’s degree in management was established in 1925. The world’s first university-based executive education program, the Sloan Fellows Program, had its beginnings at MIT in 1931 under the principal sponsorship of Alfred P. Sloan, Jr., the 1895 MIT graduate in electrical engineering who rose to the top of the General Motors Corporation. Sloan endowed the pioneering program in 1938. In 1952, a further grant from the Sloan Foundation made possible the creation of the MIT School of Industrial Management—charged with the education of “the ideal manager.” The School was renamed in honor of Mr. Sloan in 1964.

New Directions
MIT Sloan’s array of top-ranked undergraduate, graduate, and executive programs are well known for drawing on the creative and collaborative approaches common to engineering, behavioral science, economics, and management science to give managers a competitive edge. In our diverse education and research programs, we work with industry to develop the basic knowledge, insights, tools, and techniques that are shaping the future of the practice of management.

Among MIT Sloan’s key strengths are its exceptionally close ties with other world-class departments at MIT, especially in fields crucial to business, including economics, engineering, and science. One manifestation of this interdisciplinary approach is Leaders for Global Operations, an educational and research collaboration with the School of Engineering and industry partners that is transforming the practice of manufacturing and manufacturing education. Other examples include the medical innovations course, conducted in partnership with MIT Sloan, the School of Engineering, and doctors at Massachusetts General Hospital, and the new Biomedical Enterprises program.

With a focus on the future of management, MIT Sloan has been aggressive in developing leading edge research programs that have an impact on the emerging practice of business. The School has been a leader in developing the concepts of financial engineering that underlie today’s financial markets, for example. The Master of Finance, a 12-month intensive degree program designed to prepare students for careers in the financial industry, has quickly established itself as a premiere and in-demand degree program.

MIT Sloan also recently launched the MIT Executive MBA. This is a rigorous 20-month executive schedule Master of Business Administration that builds on MIT Sloan’s history of distinguished MBA programs and mid-career education.

Reflecting a world characterized by increasing economic globalization, MIT Sloan is itself an international community. Approximately one-third of the MBA class and close to half of all executive education participants come from outside the United States, and diverse research/educational collaborations have been developed with Europe, Mexico, and Asia. In addition, the School has a strong network of alumni in more than 100 countries.

As one of the world’s preeminent management schools, MIT Sloan strives to prepare its students to be principled, innovative leaders in a rapidly changing world. In an increasingly competitive environment, MIT Sloan must continually listen to the marketplace, explore new directions, and use this knowledge to develop new products, services, and processes quickly and efficiently. To maintain its leadership, MIT Sloan continues to drive change and innovation in a number of areas:

Action Learning. MIT Sloan’s signature experiential learning model immerses more students in more of the world’s under-resourced locales to translate knowledge into useful solutions. Action learning builds resilient, thoughtful leaders capable of solving unstructured problems across business functions. Global Entrepreneurship Lab, Sustainability Lab, China Lab, and India Lab are just a few of the avenues through which students can apply classroom concepts and theory to real-world business scenarios.

Entrepreneurship. The MIT Entrepreneurship Center, housed at MIT Sloan, aims to inspire, train, and coach new generations of entrepreneurs to create successful high-tech ventures. The center’s educational programs, especially New Enterprises, Entrepreneurship Lab, and Entrepreneurship Lab courses, are designed to give students the experience, skills, and network they need to turn their ideas into opportunities for new ventures and then to make those ventures successful. The center continues to work with leading practitioners and build its entrepreneurship faculty, who also conduct research on the dynamic process of high-tech venture development.

Global Initiatives. A top priority for MIT Sloan is to widen the international reach of its educational and research initiatives. MIT Sloan has international MBA programs in collaboration with China’s Sun Yat-sen, Fudan, Tsinghua, Yunnan, and Lingnan universities. MIT Sloan also hosts Chinese university faculty to help them absorb and apply MIT Sloan’s approach to management education. The School also works with Nanyang Technological University in Singapore, the Epoch Foundation in Taiwan, and Instituto Tecnológico y de Estudios Superiores in Mexico. In early 2009, MIT Sloan and the Moscow School of Management SKOLKOVO launched a series of joint programs aimed at strengthening the Russian school’s capacity in business education at the international level while exposing MIT Sloan faculty and students to a new range of global develop-
ments and challenges. Most recently, MIT Sloan began a new partnership with Sabanci University in Turkey.

**Sustainability Lab (S-Lab).** Utilizing a collaborative, interdisciplinary approach to sustainability challenges, S-Lab is jointly taught by seven of the School’s top faculty and features opportunities to work with a variety of companies as they confront environmental and social business challenges.

**China Lab.** MIT Sloan’s partnership with four premier business schools in China was expanded to include an intensive, semester-long opportunity for students from both countries to learn and work together collaboratively. Involving Chinese international MBA students and MIT Sloan students, the inaugural China Lab incorporates elements of Project Team China and the popular E-Lab and G-Lab courses to give students hands-on work experience as part of a multinational business team.

**Research Centers**

MIT Sloan’s interdisciplinary research centers include:

- Center for Computational Research and Management Science
- Center for Energy and Environmental Policy Research
- Center for Future Banking
- Center for Information Systems Research
- Institute for Work and Employment Research
- Laboratory for Financial Engineering
- Lean Advancement Initiative
- MIT Center for Collective Intelligence
- MIT Center for Digital Business
- MIT Entrepreneurship Center
- MIT Leadership Center
- MIT Workplace Center
- Operations Management Group
- Operations Research Center
- Organization Studies Group
- Productivity from Information Technology Initiative
- System Dynamics
- Virtual Customer Initiative

Information about these centers is available in the Interdisciplinary Research and Study section in Part 3 and on the MIT Sloan website, [http://mitsloan.mit.edu/faculty/research/index.php](http://mitsloan.mit.edu/faculty/research/index.php).

**Publications**

MIT Sloan produces publications that enjoy robust readerships within the MIT community, across the country, and around the world. *MIT Sloan Management Review* is a quarterly subscription-based journal for professional managers. More information about the magazine is presented on the web at [http://mitsloan.mit.edu/smr/](http://mitsloan.mit.edu/smr/).

The alumni magazine *MIT Sloan* aims to connect alumni to the School and to each other through compelling news features, faculty articles, student and alumni profiles, and class notes.

In addition, MIT Sloan maintains a dynamic website, [http://mitsloan.mit.edu/](http://mitsloan.mit.edu/), that provides access to a rich and detailed range of news and information about the School, its activities, and its resources.

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**Degrees Offered in the MIT Sloan School of Management**

<table>
<thead>
<tr>
<th>Degree</th>
<th>Course 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>- Management Science</td>
</tr>
<tr>
<td>MBA</td>
<td>- Business Administration</td>
</tr>
<tr>
<td>MFin</td>
<td>- Finance</td>
</tr>
<tr>
<td>SM</td>
<td>- Management</td>
</tr>
<tr>
<td>SM</td>
<td>- Management of Technology</td>
</tr>
<tr>
<td>SM</td>
<td>- Management Studies</td>
</tr>
<tr>
<td>SM/MBA</td>
<td>- Engineering/Management—Leaders for Global Operations</td>
</tr>
<tr>
<td>PhD</td>
<td>- Management</td>
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</tbody>
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**Operations Research**

<table>
<thead>
<tr>
<th>Degree</th>
<th>Course 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>- Operations Research</td>
</tr>
<tr>
<td>PhD</td>
<td>- Operations Research</td>
</tr>
</tbody>
</table>

**Systems Design and Management**

<table>
<thead>
<tr>
<th>Degree</th>
<th>Course 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>- Engineering and Management</td>
</tr>
</tbody>
</table>

Note: Many departments make it possible for a graduate student to pursue a simultaneous master’s degree.

The Operations Research Center is an interdepartmental center affiliated with a variety of departments from the MIT Sloan School of Management, the School of Engineering, the School of Science, and the School of Architecture and Planning. See the section on Interdisciplinary Graduate Programs in Part 3 for more information on these programs.

The Systems Design and Management Program is offered jointly by the School of Engineering and the MIT Sloan School of Management. See the section on the Engineering Systems Division in Part 2 for more information.

**Office of the Dean**

David C. Schmittlein, PhD
John C. Head III Dean
S. P. Kothari, PhD
Gordon Y Billard Professor of Management
Professor of Accounting
Deputy Dean
JoAnne Yates, PhD
Sloan Distinguished Professor of Management
Deputy Dean
Donna M. Behmer, MEd
Senior Associate Dean for Finance and Administration
Alan F. White, SM
Senior Associate Dean
Kristina Gulick Schaefer
Associate Dean of External Relations
Rochelle Weichman
Associate Dean for Executive Education
Jacob Cohen
Associate Dean for Master’s Programs
PART 2

MANAGEMENT

UNDERGRADUATE STUDY

Bachelor of Science in Management Science/Course 15

The MIT Sloan School of Management offers an undergraduate degree program in management science. This cutting-edge curriculum is designed to prepare students for top jobs in today’s technologically oriented business world. By combining the General Institute Requirements with subjects in the MIT Sloan School of Management, students learn a unique combination of technical and managerial skills, which allow them to excel in such high-demand areas as web-based commerce, financial engineering, market analysis, and software development.

In recent years, the field of management science has grown rapidly in conjunction with advances in technology, methods for collecting and structuring large quantities of data, and the building of sophisticated mathematical models. The MIT Sloan School’s undergraduate degree program develops expertise in the underlying disciplines of mathematical programming, modeling, probability, statistics, and computer technology, and a strong background in the associated disciplines of economics, accounting, communication, and managerial psychology.

Students learn to apply this knowledge within a variety of managerial functions. Each student completes a concentration of four subjects in one of four areas: finance, information technologies, marketing science, or business analytics and operations research.

MIT Sloan undergraduates take many management-related electives, alongside MBA and other graduate students. This arrangement provides an excellent opportunity for undergraduates to learn from students with previous business experience. The SB degree in management science gives students the best of both worlds—technical and managerial excellence.

Minor in Management

The Minor in Management Science introduces undergraduates in other majors to the techniques of quantitative business analysis and their application to practical problems. Its focus reflects the core content of the SB degree program in management science.

The minor consists of six subjects, four required:

15.301 Managerial Psychology Laboratory or
15.668 People and Organizations

Plus the following two subjects:
15.501 Corporate Financial Accounting
15.812 Marketing Management

Plus, any three Course 15 subjects (other than UROP, Special Studies, Special Seminars, and general-elective transfer credit) that are not designated as restricted to students in other Sloan School programs. (Two six-unit subjects will be counted as a single elective subject.) Subject 14.01 is also a permissible elective.

MINOR IN MANAGEMENT SCIENCE

The Minor in Management Science introduces undergraduates in other majors to the techniques of quantitative business analysis and their application to practical problems. Its focus reflects the core content of the SB degree program in management science.

The minor consists of six subjects, four required:

6.041 Probabilistic Systems Analysis
14.01 Principles of Microeconomics
15.053 Optimization Methods in Management Science
15.075 Statistical Thinking and Data Analysis

Plus, two Course 15 subjects selected from a list of restricted electives. (Two six-unit subjects will be counted as a single elective subject.)

INTERDEPARTMENTAL (NON-SLOAN) STUDENTS

MIT students from other departments are welcome to take unrestricted elective subjects at MIT Sloan, if they have taken the listed prerequisites. All students who wish to take Sloan graduate subjects must participate in the MIT Sloan course bidding system. Information about the process is available on the bidding website at https://sloanbid.mit.edu/. Bidding occurs at the same time as online WebSIS pre-registration in December and May for the following terms. The MIT Sloan course schedule is available on the bidding website, as are most class syllabi, to assist students in subject selection. Staff in Sloan Educational Services, Room E52-101, 617-253-1510, are always available to assist all students and provide information about MIT Sloan classes and the course bidding system.

Inquiries

For additional information about these Sloan undergraduate programs, students may consult the Office of Undergraduate Education, Room E52-430, 617-253-8614, and the MIT Sloan undergraduate website, http://mitsloan.mit.edu/undergrad/.

GRADUATE STUDY

The MIT Sloan School of Management offers opportunity for graduate study leading to the degrees of Master of Business Administration, Master of Science in Management, Master of Science in Management of Technology, Master of Finance, Master of Science in Management Studies, and Doctor of Philosophy. Dual degree options include Leaders for Global Operations with the School of Engineering (MBA/SM) and with the Harvard Kennedy School (MBA/MPP or MPA).

Entrance Requirements for Graduate Study

Applications are welcome from college graduates in all areas of concentration—the humanities, social sciences, physical sciences, and engineering. Matriculants must have completed formal subjects in calculus and in microeconomics. The minimum level of preparation is normally a one-year subject in economic theory and a one-year subject in calculus. If these subjects have not been taken in a previous academic program, applicants may be required to complete them prior to enrollment.

All applicants, including those from foreign countries, must take the Graduate Management Admission Test (GMAT). Information is available from the Graduate Management Admission Council, Educational Testing Service, Princeton, NJ 08541. MBA, MFin, doctoral program, and Leaders for Global Operations applicants may use GRE scores in place of GMAT scores.
Bachelor of Science in Management Science/Course 15

General Institute Requirements (GIRs) Subjects
Science Requirement
Humanities, Arts, and Social Sciences Requirement [two subjects can be satisfied by 14.01 and 14.02 in the Departmental Program] 6
Restricted Electives in Science and Technology (REST) Requirement [can be satisfied by 6.041 and 18.06 in the Departmental Program] 8
Laboratory Requirement [can be satisfied by 15.301 in the Departmental Program] 2
Total GIR Subjects Required for SB Degree 17

Communication Requirement
The program includes a Communication Requirement of 4 subjects:
2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and
2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

Required Subjects
1.00 Introduction to Computers and Engineering Problem Solving, 12, REST; Calculus I (GIR)
6.041 Probabilistic Systems Analysis, 12, REST; Calculus II (GIR)
14.01 Principles of Microeconomics, 12, HASS-S
14.02 Principles of Macroeconomics, 12, HASS-S
15.053 Optimization Methods in Management Science, 12
15.075 Statistical Thinking and Data Analysis, 12; 6.041*
15.279 Management Communication for Undergraduates, 12, CI-M
15.301 Managerial Psychology Laboratory, 15, LAB, CI-M
15.501 Corporate Financial Accounting, 12
18.06 Linear Algebra, 12, REST; Calculus II (GIR)

Restricted Electives Units
One of the following four subjects:
15.354 Innovation and Entrepreneurship: How to Do It, 9
15.441 Finance Theory I, 9
15.812 Marketing Management, 9
15.766 Introduction to Operations Management, 9; 6.041*

Concentration Subjects:
Two to three additional subjects as specified in one of the following four concentrations:
Finance, Information Technologies, Marketing Science, Business Analytics and Operations Research

Departmental Program Units That Also Satisfy the GIRs
(60)

Unrestricted Electives
72–90

Total Units Beyond the GIRs Required for SB Degree 180

No subject can be counted both as part of the 17-subject GIRs and as part of the 180 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

Notes
* Alternate prerequisites are listed in the subject description.

For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.

Master of Business Administration and Master of Science in Management

The MIT Sloan School MBA program offers a course of study in graduate management education, leading to a master’s degree in Business Administration (MBA) or Master of Science in Management (SM). Degree candidates are admitted in spring to a program that begins with a mandatory orientation program in August. The two-year program of study requires candidates to complete a core curriculum plus 144 units of H- or G-level elective subjects. Students also fulfill research and leadership requirements through activities in the mid-term Sloan Innovation Period and through elective coursework. Residency for four academic terms is required. A grade point average (GPA) of 4.0/5.0 (B) is required at the time of graduation.

The MBA curriculum is designed for maximum flexibility, allowing students to create an individual program best suited to their needs and career interests. During the first term, students take a sequence of core subjects with the option of one of four elective subjects.

In the first term, MBA students are assigned to one of 60 teams consisting of six to seven people. These teams are combined into six larger sections, called cohorts or oceans, for the fall core subjects. Students take all the core subjects in the same assigned section, which facilitates cohort integration and the formation of study groups.

After the first term, students have a wide range of elective subject choices. Students are given a great deal of independence in choosing their subjects, and they may design a program that includes a depth of focus as well as breadth. This includes the option of earning a certificate by enrolling in and completing the elective requirements for a track or certificate program. The MBA Program currently offers three certificates, in finance, entrepreneurship and innovation, and sustainability.

The Sloan Innovation Period, offered each term, provides students and faculty with the opportunity to explore jointly, in a nontraditional setting, what makes MIT Sloan unique: exceptional research expertise, leadership acumen, and the hands-on application of knowledge.

Practical exposure to management takes place in the MIT Sloan School through a variety of activities. Students in the MBA program are
expected to spend the summer between their first and second years working in an activity or internship that contributes to their understanding of and effectiveness in dealing with management problems.

During the academic year students have additional opportunities both in and outside the classroom to apply their learning. Many Sloan subjects incorporate action learning into their pedagogy and require students to complete projects within companies and organizations as a deliverable for the subject. These subjects may include a 1–3 week international or domestic experience working within a host organization. Corporate leaders are often invited to work with students either through guest lectureships in classes or through interaction with one of the more than 60 student organizations. Some students may also have the opportunity to work as paid teaching and research assistants to the Sloan faculty.

Outside of the classroom, the MBA community’s student organizations and clubs provide students the opportunity to practice leadership through the execution of conferences, international study tours and treks, business plan competitions, and other club-related activities.

Master of Finance
The Master of Finance (MFin) prepares students for careers in financial analysis and the financial industry. The 12-month (July–June) program consists of required fundamental and advanced subjects, restricted electives, a proseminar, general electives, an optional research practicum, and an optional master’s thesis. Practical training is an important component of a student’s preparation. MFin students are expected when possible to take advantage of the January Independent Activities Period (IAP) as an opportunity gain practical experience in an area of finance. International students must check with the International Students Office to ensure compliance with immigration regulations before participating in practical training.

To graduate, students must attain at least a B (GPA of 4.0/5.0) at the time of graduation. Residency for three consecutive academic terms (summer, fall, spring) is required unless the student obtains approval to waive the summer term. Students may not pursue another degree program while enrolled in the MFin. Except in the case of core requirements, coursework completed at MIT prior to matriculation in the MFin program may not be applied toward the MFin degree without the approval of the MFin faculty director.

In addition to the traditional synergies among finance, economics, and accounting, the program exploits intellectual ties between finance and mathematics, statistics, psychology, management, computer science, and engineering. The program is primarily targeted to recent graduates with zero to two years of experience. Recent graduates of postgraduate programs in mathematics, science, and engineering who wish to enter the finance profession are also encouraged to apply.

Required summer-term coursework provides the foundation in finance and accounting for continuing with more advanced required and elective subjects in the fall and spring terms. Restricted and general electives ensure appropriate depth as well as opportunities for breadth of study, depending on the student’s interest. The required proseminar is a project-based class in which students work in teams to address current problems identified by finance professionals. In addition, many students opt to participate in the Finance Research Practicum. This action learning experience gives students the opportunity to earn academic credit for working intensively during IAP and beyond on larger projects proposed or research questions posed by the external financial community. A thesis option is available in lieu of one or more general elective subjects for students who wish to research a topic of particular interest.

Frequent seminars, conferences, and major lectures present students with opportunities to hear from recognized leaders from a variety of industries. MFin students have full access to the extensive resources of the MIT Sloan Career Development Office as well as the MIT Career Development Center. In addition, students participate in a wide array of professional clubs, student government, sports teams, and organizations at the school and campus level.

Applications to the MFin program are due in early November (Round 1) and early January (Round 2); decisions are announced in early March.

Master of Science in Management Studies
The Master of Science in Management Studies (MSMS) program is a customizable advanced master’s degree for students in non-US business schools. Already having completed their MBA (or comparable master’s degree) core classes at international universities, MSMS students specialize in a particular area of management by taking elective subjects and working with a Sloan professor to write a compulsory master’s thesis. Applicants from our international partner and cooperating schools are especially encouraged to apply.

The 9-month program, which runs from September to June, requires full-time residence. In addition, MSMS students are required to meet MIT’s requirement of at least 66 units of G- or H-level subjects, of which at least 42 units must be H-level, and a master’s thesis. To graduate, students must attain a GPA of 4.0/5.0 (B) by the time of graduation. For more information, visit http://mitsloan.mit.edu/msms/.

System Design and Management Program: Master of Science in Engineering and Management
Jointly sponsored by the School of Engineering and the MIT Sloan School, the System Design and Management (SDM) program targets experienced engineers and product development professionals who seek to build upon their technical background and advance to positions of leadership in their careers.

The SDM program was created in 1996, in response to a critical need expressed by government and industry to provide future engineering leaders with an educational experience that combines an engineering systems perspective with the essentials of a management education. The program has focused on developing competencies in the areas of systems thinking, management skills, leadership, and an end-to-end understanding of systems development.

SDM is offered in three formats, including a 13-month full-time on-campus program and two career-compatible 24-month programs—half-time on campus for local-area commuter students and a distance delivery option via synchronous video conferencing. SDM is the only MIT degree program that can be completed primarily through distance education.
Program applicants have significant engineering and/or managerial experience, in addition to a scientific or engineering education. On average, SDM student-fellows have about 10 years of work experience. The program participants come from both private and government institutions, either as company sponsored, or as self-sponsored students. A majority of SDM students have advanced degrees in other fields, and over half come from countries other than the United States.

The SDM program begins in January. Applications are accepted on a continuous basis, with an early notification deadline of May 15 and a final cutoff of October 15 for admission to the next cohort. For additional information, contact the SDM Program Office, Room E46-315, 617-253-1055, sdm@mit.edu, or visit http://sdm.mit.edu/. See also Engineering Systems Division in Part 2.

Leaders for Global Operations Program: Dual Master's Degrees in Management and Engineering

The 24-month Leaders for Global Operations (LGO) program combines graduate education in engineering and management for those with two or more years of full-time work experience who aspire to leadership positions in manufacturing or operations companies. A required six-month internship comprising a research project at one of LGO’s partner companies leads to a dual-degree thesis, culminating in two master’s degrees—an MBA (or SM in management) and an SM in engineering. The program is offered jointly through the MIT Sloan School of Management and the School of Engineering master’s programs in Aeronautics and Astronautics, Biological Engineering, Chemical Engineering, Civil and Environmental Engineering, Electrical Engineering and Computer Science, Engineering Systems, and Mechanical Engineering. For more information, general requirements, and application procedures, visit the LGO website at http://lgo.mit.edu/.

Doctor of Philosophy

The purpose of the MIT Sloan School’s PhD program is to prepare students for careers in teaching and research or, to a lesser extent, for positions requiring advanced research and analytical capabilities. The PhD program provides the opportunity to combine in-depth work in theory with work in broadly defined “applied” areas, with faculty who are experts in their fields.

A candidate entering with a bachelor’s degree should be able to complete the program in four or five 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, two or three years are required for the doctoral dissertation.

Major and Minor Fields

Candidates must master the literature, theory, and application of a major field of concentration as well as a minor field. Successful completion of this requirement is determined by General Examinations. The major fields currently available in the MIT Sloan School are:

- Accounting and Control
- Economic Sociology
- Finance
- Information Technologies
- Marketing
- Operations Management
- Organization Studies
- System Dynamics
- Technological Innovation, Entrepreneurship, and Strategic Management
- Work and Employment Research

PhD candidates enter the program with a clear idea in mind of a concentration. An appropriate minor field is then selected—typically a theoretical discipline that provides a foundation for research in the major field. Major fields such as accounting or marketing usually have economics as a minor field, while organization studies has behavioral science.

The subject requirements for the major and minor fields are not rigid. There are normal groups of subjects for the standard fields, but substitutions of other subjects and independent study are possible. Regardless of the major and minor fields chosen, a plan of study designed to prepare the student for General Examinations is worked out by the student and his or her faculty advisor(s).

The General Examinations normally are taken at the end of the second year or beginning of the third year of study, after completion of major and minor field coursework and a research paper (see below). The exact form of general exams varies and may involve written examinations, critiques of research papers, or review papers on prescribed topics. In all cases, the last stage is an oral examination.

The MIT Sloan School is committed to research, and the philosophy and structure of the PhD program reflect this professional commitment. There are two separate research requirements: the second-year research paper and the thesis.

A substantial part of the student’s work in the latter half of the first year and in the second year is devoted to an independent research project. The topic, design, and execution of the project are left to the student, while advice and criticism are provided by a research advisor and other interested faculty. Upon completion of the project, the student prepares a document known as the “second-year paper.”

The PhD dissertation consists of significant scholarly research in some area of management. Close working relationships with faculty are established early so that the thesis can be defined as a manageable project as early as possible. Candidates typically require two or three years of full-time work to complete their theses.

There is no language requirement in the MIT Sloan School’s PhD program, although in some cases the student and his or her advisor may decide that further study of a foreign language is necessary if the student is to work effectively in his or her major field.

Teaching and Research Assistantships

All doctoral students in the MIT Sloan School are eligible to apply for the approximately 100 part-time research and teaching assistantships available each year.

Inquiries

For information on MIT Sloan programs, visit http://mitsloan.mit.edu/.
The program brings together rising executives from diverse industries to collaborate on the complex challenges they face now—and will face in years to come—within their organizations and within the larger international marketplace. Although a large proportion of MIT EMBA students come from careers in life science, engineering, and technology, our ranks also include leaders in government, start-ups, nonprofits, finance, and the military. All are inspired by this rare opportunity to drive positive change, master the science of management, and integrate global leadership and data-driven analytics.

For more information about the MIT Executive MBA and how to apply, visit http://mitsloan.mit.edu/executivemba/ or contact the program office, Room E52-325, 617-253-5033, executivemba@mit.edu.

OTHER PROGRAMS

Computation for Design and Optimization

The Computation for Design and Optimization (CDO) program offers a master’s degree to students interested in the analysis and application of computational approaches to designing and operating engineered systems. The curriculum is designed with a common core serving all engineering disciplines and an elective component focusing on specific applications. Current MIT graduate students may pursue a CDO master’s degree in conjunction with a department-based master’s or PhD program. For more information, see the full program description under Interdisciplinary Graduate Programs in Part 3, or visit http://computationalengineering.mit.edu/education/.

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Above all, science is elegant, beautiful, and mysterious; it ennobles the human spirit. It is a privilege—whether for a semester, four years, or a lifetime—to attempt to understand nature at its most fundamental level. In the School of Science, research and education are inextricably interwoven, and our faculty is committed to excellence in both endeavors.
The School of Science is an amazing enterprise: with approximately 330 faculty members, 1,200 graduate students, 900 undergraduate majors, and comparable numbers of postdoctoral researchers and research staff, the School is large enough to carry out research at the frontiers in every field of science. Our faculty members have won 16 Nobel Prizes and our alumni have won another 16, most of which have been awarded in the past 20 years. The six departments in the School are consistently rated among the best in the world.

The School is a prolific generator of new knowledge. Some members of our community study deep philosophical questions: What is the nature of dark matter and dark energy, which make up 95 percent of the content of our universe? How does our brain, a complex system of interconnected neurons, give rise to our mind—our consciousness and ability to learn? Other faculty members study problems that have obvious practical implications: How does global warming increase the intensity of hurricanes? Can we make adult stem cells capable of generating any cells in the body, replacing cells damaged by disease without using embryos?

However, the deep commitment to education found in the School of Science makes MIT unique among the great research universities. MIT provides each of its undergraduates with an understanding of the basic elements of biology, chemistry, mathematics, and physics, and our Science faculty are devoted to doing this well. Some of our most famous faculty members, even a few with Nobel Prizes, are some of the best teachers of our freshman subjects.

Our science majors are provided with the very best introduction to their chosen field and the opportunity to participate in leading-edge research. Whether our undergraduates go on to graduate studies in science or a professional school in an area such as medicine, law, business, or engineering, they will be superbly prepared for their careers after MIT. Many of our graduate students have pursued distinguished careers in research and education; however, others enjoy equally satisfying careers in business, industry, and government. Combining their PhD degrees in science with medical, law, or business degrees, our graduate students are uniquely capable of making creative contributions to the modern world.

For more information about the School of Science, visit [http://web.mit.edu/science/](http://web.mit.edu/science/).

History
Science has been at the core of an MIT education since the Institute’s founding in 1861 by the distinguished natural scientist, William Barton Rogers. The earliest offerings in chemistry, geology, and general science were expanded to include physics, mathematics, and biology, and then consolidated as the School of Science under the leadership of Karl Taylor Compton in 1932. During Compton’s tenure and into the postwar years, the Institute saw vast growth in the physical sciences as federal funding for basic research increased. In 1969, the Geology Department became the Department of Earth and Planetary Sciences, and when it merged with the Department of Meteorology and Physical Oceanography in 1983, it evolved into the present-day Department of Earth, Atmospheric and Planetary Sciences.

As the life sciences attained new prominence in the 1970s and 1980s, the Department of Biology grew with the additions of the Center for Cancer Research (now the Koch Institute for Integrative Cancer Research) and the Whitehead Institute for Biomedical Research. In 1994, the Department of Brain and Cognitive Sciences (BCS) moved from the Whitaker College of Health Sciences and Technology to the School of Science. Recently, BCS joined with the Picower Institute for Learning and Memory expanding the School-wide resources for research in the neurosciences.

Science Laboratories and Centers
Much of our research in science is carried out in large research laboratories and centers like the Whitehead and Picower institutes, where the kinds of facilities necessary for research are available and collaboration among research groups is encouraged. Laboratories and centers with strong participation by members of the School of Science include:

- Broad Institute of MIT and Harvard
- Center for Global Change Science
- Earth Resources Laboratory
- Laboratory for Nuclear Science
- MIT Kavli Institute for Astrophysics and Space Research
- Picower Institute for Learning and Memory
- Whitehead Institute for Biomedical Research

Collaboration with the School of Engineering
One of the great strengths of MIT is that school and departmental boundaries are invisible. Many School of Science faculty members carry out research in collaboration with others in the School of Engineering, often in inter-school laboratories, such as the Center for Materials Science and Engineering, the Research Laboratory of Electronics, or the Institute for Soldier Nanotechnologies. Joint programs, such as the Singapore–MIT Alliance, the Microbiology program, or the Computational and Systems Biology program, also provide significant opportunities for inter-school collaboration. Research in science is often facilitated by the outstanding facilities developed to support engineering research and education, such as the Microsystems Technology Laboratories.

For more information about interdisciplinary laboratories, centers, and programs, see Part 3.
## Degrees Offered in the School of Science

### Biology  Course 7

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<td>PhD</td>
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<td>PhD</td>
<td>Biochemistry</td>
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<td>PhD</td>
<td>Biological Oceanography (jointly offered with WHOI)</td>
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<td>PhD</td>
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<td>PhD</td>
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</table>

### Brain and Cognitive Sciences  Course 9

<table>
<thead>
<tr>
<th>Degree</th>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB</td>
<td>Brain and Cognitive Sciences</td>
</tr>
<tr>
<td>PhD</td>
<td>Cognitive Science</td>
</tr>
<tr>
<td>PhD</td>
<td>Neuroscience</td>
</tr>
</tbody>
</table>

### Chemistry  Course 5

<table>
<thead>
<tr>
<th>Degree</th>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB</td>
<td>Chemistry</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td>Biological Chemistry</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td>Inorganic Chemistry</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td>Organic Chemistry</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td>Physical Chemistry</td>
</tr>
</tbody>
</table>

### Computational and Systems Biology  Course CSB

<table>
<thead>
<tr>
<th>Degree</th>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD</td>
<td>Computational and Systems Biology (jointly offered with the School of Engineering)</td>
</tr>
</tbody>
</table>

### Earth, Atmospheric, and Planetary Sciences  Course 12

<table>
<thead>
<tr>
<th>Degree</th>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB</td>
<td>Earth, Atmospheric, and Planetary Sciences</td>
</tr>
<tr>
<td>SM</td>
<td>Atmospheric Science</td>
</tr>
<tr>
<td>SM</td>
<td>Chemical Oceanography (jointly offered with WHOI)</td>
</tr>
<tr>
<td>SM</td>
<td>Climate Physics and Chemistry</td>
</tr>
<tr>
<td>SM</td>
<td>Earth and Planetary Sciences</td>
</tr>
<tr>
<td>SM</td>
<td>Marine Geology and Geophysics (jointly offered with WHOI)</td>
</tr>
<tr>
<td>SM</td>
<td>Physical Oceanography (jointly offered with WHOI)</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td>Atmospheric Chemistry</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td>Atmospheric Science</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td>Chemical Oceanography (jointly offered with WHOI)</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td>Climate Physics and Chemistry</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td>Geochemistry</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td>Geology</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td>Geophysics</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td>Marine Geology and Geophysics (jointly offered with WHOI)</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td>Physical Oceanography (jointly offered with WHOI)</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td>Planetary Sciences</td>
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</table>

### Mathematics  Course 18

<table>
<thead>
<tr>
<th>Degree</th>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB</td>
<td>Mathematics</td>
</tr>
<tr>
<td>SB</td>
<td>Mathematics with Computer Science</td>
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<tr>
<td>PhD</td>
<td>Mathematics</td>
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### Microbiology

<table>
<thead>
<tr>
<th>Degree</th>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD</td>
<td>Microbiology</td>
</tr>
</tbody>
</table>

### Notes

Many departments make it possible for a graduate student to pursue a simultaneous master’s degree.

Several departments also offer undesignated degrees, which lead to the Bachelor of Science without departmental designation. The curricula for these programs offer students opportunities to pursue broader programs of study than can be accommodated within a four-year departmental program.

(1) See Interdisciplinary Graduate Programs section in Part 3.

---

### Office of the Dean

Marc A. Kastner, PhD
Donner Professor of Physics
Dean

Hazel Louise Sive, PhD
Professor of Biology
Member, Whitehead Institute for Biomedical Research
Associate Dean

Elizabeth Chadis, BA
Assistant Dean for Development

James White, MS, CPA, CMA
Assistant Dean for Finance

Heather G. Williams, MA
Assistant Dean for Administration and Human Resources
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, 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, which emphasize 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.

UNDERGRADUATE STUDY

Bachelor of Science in Biology/Course 7
The curriculum leading to the Bachelor of Science in 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 many graduates choose to continue their education at a graduate school in order to obtain a PhD in an area such as biochemistry, microbiology, genetics, biophysics, cell biology, or physiology, followed by research or teaching in one of those areas. The undergraduate curriculum is also excellent preparation for students who wish to continue their education toward an MD, particularly if their career plans include laboratory investigations bearing on human disease.

Bachelor of Science in Biology/Course 7-A
Course 7-A is designed for students who wish to obtain a background in biology as preparation for careers without laboratory research. Course 7-A has the same core requirements as Course 7, but does not require a 30-unit laboratory subject within its Restricted Electives.

Students are encouraged to use their elective subjects for more advanced subjects in their field and for additional study in basic and advanced subjects offered in various departments.

Additional information regarding undergraduate academic programs and research opportunities may be obtained from the Biology Education Office, Room 68-120, 617-253-4718, undergradbio@mit.edu.

Bachelor of Science in Computer Science and Molecular Biology/Course 6-7
The Department of Biology jointly offers a Bachelor of Science in Computer Science and Molecular Biology with the Department of Electrical Engineering and Computer Science. A detailed description of the requirements for this degree program can be found under Interdisciplinary Undergraduate Programs and Minors in Part 3.

Minor in Biology
The requirements for a Minor in Biology are as follows:

5.12 Organic Chemistry I
7.03 Genetics
7.05 General Biochemistry
Two additional subjects from:
7.02I or 20.109; 7.06, 7.08I, 7.20I, 7.21,
7.22, 7.23, 7.25, 7.26, 7.27, 7.28, 7.29I,
7.30, 7.31, 7.32I, 7.33, 7.35, 7.36, 7.37I,
7.41, and 7.49I.

For a general description of the minor program, see Undergraduate Education in Part 1.

GRADUATE STUDY

The Department of Biology offers graduate work leading to the Doctor of Philosophy. Study may be pursued in the following fields of specialization.

Biochemistry is the study of enzyme catalysis, and the chemical properties of proteins, carbohydrates, complex lipids, nucleic acids, and protein-nucleic acid complexes. Methods of analysis include gene cloning, the use of genetic variants, synthetic substrates, and transition state analogs. Specific areas of study include the chemistry of oncogenes, mechanism of RNA splicing, analysis of cytoskeletal proteins, chemistry of blood coagulation, mechanism of ion pumps and photoreceptors, and the role of complex carbohydrates in cell surface function and protein compartmentalization.

Biophysical chemistry and molecular structure focuses on studies of the principles that underlie the folding, stability, molecular design, and assembly of proteins and nucleic acids. Analysis of molecular structure includes X-ray crystallography and nuclear magnetic resonance. Specific areas of concentration include the study of genetic strategies for enhancing the stability, ligand affinity, and catalytic efficiency of proteins and enzymes; pathways of protein folding; protein-nucleic acid recognition; and antigen-antibody interactions. Studies of more complex systems include the control of viral and cytoskeletal assembly.

Cell biology refers to molecular biological, genetic, and cell biological analysis of eukaryotic cells. The specific areas of research include the organization, expression, and regulation of eukaryotic genomes; structure and function of membranes and cytoskeletons; molecular basis of cellular structure, organization, proliferation, and movement; differentiation and functions of specialized cell types; and the molecular basis of various diseases.

Chemistry/Biology interface research area pervades the fields of biomedicine, cell and developmental biology, bioimaging, structural biology, enzymology, and synthetic biology. These areas of investigation are well represented at MIT, where a common theme is the application of rigorous physical and chemical methods to the molecular dissection of biological pathways, reactions, and circuits. The Chemistry/Biology Interface program at MIT provides a training mechanism that maintains academic depth within the core areas of chemistry, physics, biology, and engineering, but also provides disciplinary breadth. The Chemistry/Biology Interface is designed to bring together faculty and students from the Departments of Chemistry, Biology, and Biological Engineering, spanning the Schools of Science and Engineering.

Computational and systems biology is a recent area of emphasis in the department offered jointly with the Department of Electrical Engineering and Computer Science and the Division of Biological Engineering as part of the Computational and Systems Biology Initiative (CSBI).
Bachelor of Science in Biology/Course 7

General Institute Requirements (GIRs)

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement [two subjects can be satisfied by 5.111, 5.112, or 3.091, and 7.012, 7.013, or 7.014 in the Departmental Program]</td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>8</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement [can be satisfied from among 5.12, 5.60(\text{GIR}) and 7.03 or 7.05 in the Departmental Program]</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement [can be satisfied by 7.02] in the Departmental Program(\text{GIR})</td>
<td>1</td>
</tr>
</tbody>
</table>

Total GIR Subjects Required for SB Degree: 17

Communication Requirement

The program includes a Communication Requirement of 4 subjects:

- 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and
- 2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program

Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

<table>
<thead>
<tr>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.111 or 5.112 Principles of Chemical Science, 12, Chemistry (GIR) or 3.091 Introduction to Solid-State Chemistry, 12, Chemistry (GIR)</td>
<td>99–102</td>
</tr>
<tr>
<td>5.12 Organic Chemistry I, 12, REST; Chemistry (GIR)</td>
<td></td>
</tr>
<tr>
<td>20.110(\text{GIR}) Thermodynamics of Biomolecular Systems, 12, REST; Calculus II (GIR), Chemistry (GIR) or 7.100 Physical Chemistry of Biomolecular Systems, 12; Calculus II (GIR), Chemistry (GIR), Physics I (GIR), Physics II (GIR) or 5.60 Thermodynamics and Kinetics, 12, REST; Calculus II (GIR), Chemistry (GIR)</td>
<td></td>
</tr>
<tr>
<td>7.012 or 7.013 or 7.014 Introductory Biology, 12</td>
<td></td>
</tr>
<tr>
<td>7.020 Introduction to Experimental Biology and Communication, 18, LAB, CI-M; Biology (GIR) or 20.109 Laboratory Fundamentals in Biological Engineering, 15, LAB, CI-M; Biology (GIR), Chemistry (GIR), 6.00, 18.03, 20.110*</td>
<td></td>
</tr>
<tr>
<td>7.030 Genes, 12, REST; Biology (GIR)</td>
<td></td>
</tr>
<tr>
<td>7.050 General Biochemistry, 12, REST; Biology (GIR)*</td>
<td></td>
</tr>
<tr>
<td>5.07 Biological Chemistry I, 12; 5.12</td>
<td></td>
</tr>
<tr>
<td>7.06 Cell Biology, 12; 7.033, 7.05</td>
<td></td>
</tr>
</tbody>
</table>

Restricted Electives

Three undergraduate-level 12-unit subjects offered by the Department of Biology for which 7.03 and/or 7.05 are prerequisites. Exceptions: 7.30J is eligible as a restricted elective; 7.19J cannot be used as a restricted elective. Graduate-level subjects may not be used as restricted electives. Subjects that count as restricted electives are the following: 7.08J, 7.20J, 7.21, 7.22, 7.23, 7.25, 7.26, 7.27, 7.28, 7.29J, 7.30J, 7.31J, 7.33, 7.35, 7.36, 7.37, 7.41, and 7.49J.

One of the 30-unit project laboratory subjects in the department curriculum. Those currently offered are:

- 7.13 Experimental Microbial Genetics, 30, CI-M; 7.02, 7.03, 7.05
- 7.16 Experimental Molecular Biology: Biotechnology II, 30, CI-M; 7.02, 7.03, 7.05
- 7.18 Topics in Experimental Biology, 30, CI-M; 7.02, 7.03, 7.05

Departmental Program Units That Also Satisfy the GIRs

| (60) |

Unrestricted Electives

| (60) |

Total Units Beyond the GIRs Required for SB Degree

| 180 |

No subject can be counted both as part of the 17-subject GIRs and as part of the 180 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.
logical approaches. Of particular interest is the role of idiotypic and cellular interactions in the regulation of the immune system as studied by organ culture, hybridoma technology, and the behavior of transgenic mice.

Neurobiology is an area of recent emphasis in the department. The subject in general neurobiology is supplemented by a seminar series and an interlaboratory journal club. Students admitted to the Biology graduate program can join the Molecular and Cellular Neurosciences Program, offering access to participating faculty and neuroscience coursework across campus. The emphasis is on neuronal development, synaptic plasticity, and neurological and psychiatric disease, primarily using cell-biological, electrophysiological, imaging, and genetic approaches. Current areas of research interest include the molecular determinants of neuronal diversity and shape; the formation and function of synapses and neural networks; and the genetic and molecular determinants of memory storage, sensory transduction, and neuropsychiatric disease.

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 admission to graduate study as follows: 18.01, 18.02 Calculus; one year of college physics; 5.12 Organic Chemistry I; professional subjects including general biochemistry, genetics, and physical chemistry. However, students may make up some deficiencies over the course of their graduate work.

Doctor of Philosophy
The General Degree Requirements for the Doctor of Philosophy are listed under Graduate Education in Part 1. In the departmental program, each graduate student is expected to acquire a solid background in four fundamental areas of biology: biochemistry, genetics, cell biology, and molecular biology. Most students take subjects in these areas during the first year. All students are required to take three subjects: 7.52 Genetics for Graduate Students, 7.51 Principles of Biochemical Analysis, and 7.50 Method and Logic in Molecular Biology. This last subject is a seminar designed specifically to introduce graduate students to in-depth discussion and analysis of topics in molecular biology.

Students have a choice of several elective subjects, which have been designed for the entering graduate student. One of the elective subjects must focus on computational and quantitative approaches to biology. Typically students choose between the following three subjects: 7.57 Quantitative Biology for Graduate Students, 7.81 Systems Biology, or 7.91 Foundations of Computational and Systems Biology. In addition to providing a strong formal background in biology, the first-year program serves to familiarize the students with faculty and students in all parts of the department.

Joint Program with the Woods Hole Oceanographic Institution/Course 7-W
MIT and the Woods Hole Oceanographic Institution administer a joint program in biological oceanography leading to a jointly awarded Doctor of Philosophy. The program is described at the end of Part 3.

Financial Support
Students who are accepted into the graduate program are provided with support from departmental training grants, departmental funds for teaching assistants, and research grants. In addition, some students bring NSF and other competitive fellowships. Through these sources, full tuition plus a stipend for living expenses are provided.

Students are encouraged to apply for outside fellowships for which they are eligible, such as the National Science Foundation Fellowships. Information regarding graduate student fellowships is available at most colleges from the career planning office.

Inquiries
Additional information regarding graduate academic programs, research activities, admissions, financial aid, and assistantships may be obtained from the Biology Education Office, Room 68-120, 617-253-3717, gradbio@mit.edu.

Faculty and Teaching Staff
Tania Baker, PhD
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Howard Hughes Medical Institute Investigator
MacVicar Faculty Fellow
Department Head

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Associate Department Head

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Associate Director, David H. Koch Institute for Integrative Cancer Research
Associate Department Head

Peter Reddien, PhD
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Howard Hughes Medical Institute Early Career Scientist
Associate Member, Broad Institute
Associate Member, Whitehead Institute for Biomedical Research
Associate Department Head
Bachelor of Science in Biology/Course 7-A

General Institute Requirements (GIRs)  
Subjects

| Science Requirement [two subjects can be satisfied by 5.111, 5.112, or 3.091, and 7.012, 7.013, or 7.014] | 6 |
| Humanities, Arts, and Social Sciences Requirement | 8 |
| Restricted Electives in Science and Technology (REST) Requirement [can be satisfied from among 5.12, 5.60(1) and 7.03 or 7.05 in the Departmental Program] | 2 |
| Laboratory Requirement [can be satisfied by 7.02] in the Departmental Program(2) | 1 |

Total GIR Subjects Required for SB Degree 17

Communication Requirement  
The program includes a Communication Requirement of 4 subjects: 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and 2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program  
Required Subjects  
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

| Required Subjects | Units |
| 5.111 or 5.112 Principles of Chemical Science, 12, Chemistry (GIR) or 3.091 Introduction to Solid-State Chemistry, 12, Chemistry (GIR) | 99–102 |
| 5.12 Organic Chemistry I, 12, REST; Chemistry (GIR) | |
| 20.110J* Thermodynamics of Biomolecular Systems, 12, REST; Calculus II (GIR), Chemistry (GIR) or 7.10J* Physical Chemistry of Biomolecular Systems, 12; Calculus II (GIR), Chemistry (GIR), Physics I (GIR), Physics II (GIR) | |
| 5.60 Thermodynamics and Kinetics, 12, REST; Calculus II (GIR), Chemistry (GIR) | |
| 7.012 or 7.013 or 7.014 Introductory Biology, 12, Biology (GIR) | |
| 7.02J* Introduction to Experimental Biology and Communication, 18, LAB, CI-M; Biology (GIR) or 20.109 Laboratory Fundamentals in Biological Engineering, 15, LAB, CI-M; Biology (GIR), Chemistry (GIR), 6.00, 18.03, 20.110* | |
| 7.03 Genetics, 12, REST; Biology (GIR) | |
| 7.05 General Biochemistry, 12, REST; Biology (GIR)* | |
| 5.07 Biological Chemistry I, 12; 5.12 | |
| 7.06 Cell Biology, 12; 7.03, 7.05 | |

Restricted Electives(1) 48  
Three undergraduate-level 12-unit subjects offered by the Department of Biology for which 7.03 and/or 7.05 are prerequisites. Graduate-level subjects may not be used as restricted electives. Subjects that count as restricted electives are the following: 7.04J, 7.05J, 7.11, 7.22, 7.23, 7.24, 7.26, 7.27, 7.28, 7.29J, 7.30J, 7.31J, 7.32J, 7.33, 7.35, 7.36, 7.37J, 7.41, and 7.49J.

One of the following CI-M subjects: 3.014, 5.06, 5.38, 7.19, 7.30J, 7.49J, 8.13, 9.02, 9.12, 10.26, 10.27, 10.28, 10.29, 20.380, or 6.012J.

Departmental Program Units That Also Satisfy the GIRs (60)

Unrestricted Electives 90–93

Total Units Beyond the GIRs Required for SB Degree 180  
No subject can be counted both as part of the 17-subject GIRs and as part of the 180 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

Notes  
*Alternate prerequisites are listed in the subject description.

1(1)The department recommends 20.110J, 7.10J, or 5.60 to fulfill the biology requirements, but will also accept 2.005, 3.012, 8.044, or 10.212 as a substitution.

(2)7.30J or 7.49J may be selected from either group, but neither subject can be selected from both groups.  
For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.
Associate Professors
Laurie A. Boyer, PhD
Associate Professor of Biology without Tenure

Iain Cheeseman, PhD
Thomas D. and Virginia W. Cabot Career Development Associate Professor of Biology without Tenure
Associate Member, Whitehead Institute for Biomedical Research

Michael Hemann, PhD
Associate Professor of Biology
Associate Member, Broad Institute

Amy Keating, PhD
Sizer Career Development Associate Professor of Biology
Associate Member, Broad Institute

Dennis Kim, PhD
Associate Professor of Biology

Michael Laub, PhD
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Associate Member, Broad Institute

Elly Nedivi, PhD
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Aviv Regev, PhD
Burroughs Wellcome Fund Career Development Associate Professor of Biology
Howard Hughes Medical Institute Early Career Scientist
Associate Member, Broad Institute

Jeroen P. J. Saeij, PhD
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Associate Member, Broad Institute

Thomas Schwartz, PhD
Associate Professor of Biology

Assistant Professors
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Linda and Howard Stern Career Development Assistant Professor of Biology

Mary Gehring, PhD
Assistant Professor of Biology

Wendy Gilbert, PhD
Swanson Career Development Assistant Professor of Biology

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Mandana Sassanfar, PhD

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Chu Choi, PhD
Huiming Ding, PhD
Sanjay D’Souza, PhD
Sanjib Dutta, PhD
James J. Foti, PhD
Steven E. Glynn, PhD
Robert Grant, PhD
Ash Jacob, PhD
Noriko Kobayashi, PhD
Caroline Koehler, PhD
Kazuhiko Kurosawa, PhD
Jin Ah Kwon, PhD
Catherine Lee, PhD
Ky Lowenhaupt, PhD
Debabrata Mandal, PhD
Brenda Minesinger, PhD
Shmulik Motola, PhD
John F. W. Quimby, PhD
Kirith Reddy, PhD
T. Sambandan, PhD
Janet L. Smith, PhD
Eric Spear, PhD
Mohan Viswanathan, PhD
Robert P. Weinberg, PhD
Matthew Youngman, PhD
Kun Xie, PhD

Professors Emeriti
David Baltimore, PhD
Professor of Biology, Emeritus

Gene Brown, PhD
Professor of Biochemistry, Emeritus

Arnold Lester Demain, PhD
Professor of Industrial Microbiology, Emeritus

Herman Nathaniel Eisen, MD
Professor of Immunology, Emeritus

Maurice Sanford Fox, PhD
Professor of Molecular Biology, Emeritus

Malcolm Lawrence Gefter, PhD
Professor of Biochemistry, Emeritus

Irving M. London, MD
Grover M. Hermann Professor of Health Sciences and Technology, Emeritus

Professor of Biology and Medicine, Emeritus

Boris Magasanik, PhD
Jacques Monod Professor of Microbiology, Emeritus

Sheldon Penman, PhD
Professor of Cell Biology, Emeritus

Phillips Wesley Robbins, PhD
Professor of Biochemistry, Emeritus

Robert Daniel Rosenberg, MD, PhD
Whitehead Professor of Biology, Emeritus

Paul Reinhard Schimmel, PhD
John D. MacArthur Professor of Biochemistry and Biophysics, Emeritus

Ethan Royal Signer, PhD
Professor of Biology, Emerita

Annamaria Torriani, PhD
Professor of Biology, Emerita
The study of mind, brain, and behavior has grown in recent years with unprecedented speed. New avenues of approach, opened by developments in the biological and computer sciences, raise the hope that human beings, who have achieved considerable mastery over the world around them, may also come closer to an understanding of themselves. The goal of the Department of Brain and Cognitive Sciences is to answer fundamental questions concerning intelligent processes and brain organization. To this end, the department focuses on four themes: molecular and cellular neuroscience, systems neuroscience, cognitive science, and computation. Several members of the department’s faculty are affiliated with two major research centers: the Picower Institute for Learning and Memory and the McGovern Institute for Brain Research.

Research in cellular neuroscience deals with the biology of neurons, emphasizing the special properties of these cells as encoders, transmitters, and processors of information. Departmental researchers apply techniques of contemporary molecular and cellular biology to problems of neuronal development, structure, and function, resulting in new understanding of the underlying basic components of the nervous system and their interactions. These studies have profound clinical implications, in part by generating a framework for the treatment of neurological and psychiatric disorders. Primary areas of interest include the development and plasticity of neuronal morphology and connectivity, the cellular and molecular bases of behavior in simple neuronal circuits, neurochemistry, and cellular physiology.

In the area of systems neuroscience, departmental investigators use a number of new approaches ranging from computation through electrophysiology to biophysics. Of major interest are the visual and motor systems where the scientific goals are to understand transduction and encoding of sensory stimuli into nerve messages, organization and development of sensorimotor systems, processing of sensorimotor information, and the sensorimotor performance of organisms. Also of major interest is neural and endocrine regulation, where the scientific goal is to understand the effects of circulating compounds on brain composition and behavior.

In computation and cognitive science, particularly strong interactions exist between the Department of Brain and Cognitive Sciences, the Computer Science and Artificial Intelligence Laboratory, and the Center for Biological and Computational Learning, providing new intellectual approaches in areas including vision and motor control, and biological and computer learning. Computational theories are developed and tested within the framework of neurophysiological, psychological, and other experimental approaches. In the study of vision and motor control, complementary experimental work includes single-cell and multiple-cell neurophysiological recording as well as functional brain imaging. In the area of learning, which is seen as central to intelligent behavior, departmental researchers along with members of the Center for Biological and Computational Learning are working to develop theories of vision, motor control, neural circuitry, and language within an experimental framework.

In cognitive science, human experimentation is combined with formal and computational analyses to understand complex intelligent processes such as language, reasoning, memory, and visual information processing. There are applications in the fields of education, artificial intelligence, human-machine interaction, and in the treatment of language, cognitive, and other disorders.

Subfields in cognitive science include psycholinguistics, comprising sentence and word processing, language acquisition, and aphasia; visual cognition, including reading, imagery, attention, and perception of complex patterns such as faces, objects, and scenes; spatial cognition; memory; and the nature and development of concepts. Another key field is the study of perception—developmental and processing approaches focus on human and machine vision, and how visual images are encoded, stored, and retrieved, with current topics that include motion analysis, stereopsis, perceptual organization, and perceptual similarity. Other research includes functional brain imaging in normal subjects as well as studies of neurologically impaired patients in an attempt to understand brain mechanisms underlying normal human sensation, perception, cognition, action, and affect.

**UNDERGRADUATE STUDY**

**Bachelor of Science in Brain and Cognitive Sciences/Course 9**

Brain science and cognitive science are complementary and interactive in their research objectives. Both approaches examine perception, performance, and intervening processes in humans and animals. Central issues in the discipline include the interpretation of sensory experience; the reception, manipulation, storage, and retrieval of information within the nervous system; and the planning and execution of motor activity. Higher level functions include the development of formal and informal reasoning skills; and the structure, acquisition, use, and internal representation of human language.

The Bachelor of Science in Brain and Cognitive Sciences prepares students for careers in neuroscience, medicine, cognitive science, psychology, linguistics, philosophy, or aspects of artificial intelligence (particularly those aspects concerned with vision) as well as for further work in the area of efficient human-machine interaction.

Methods of inquiry in the brain and cognitive sciences are drawn from molecular, cellular, and systems neuroscience; cognitive and perceptual psychology; computer science and artificial intelligence; linguistics; philosophy of language and mind; and mathematics. The undergraduate program is designed to provide instruction in the relevant aspects of these various disciplines. The program is administered by an Undergraduate Officer and an Undergraduate Administrator, consulting as necessary with faculty members from these disciplines who also serve as advisors to majors, helping them select a coherent set of subjects from within the requirements, including a research requirement. Members of the faculty are available to guide the research.

**Minor in Brain and Cognitive Sciences**

The Minor in Brain and Cognitive Sciences consists of six subjects arranged in two tiers of study, intended to provide students breadth in the field as a whole and some depth in one of two areas of specialization.
Bachelor of Science in Brain and Cognitive Sciences/Course 9

<table>
<thead>
<tr>
<th>General Institute Requirements (GIRs)</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
<td></td>
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<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>8</td>
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<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>2</td>
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</tr>
<tr>
<td>Laboratory Requirement</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total GIR Subjects Required for SB Degree</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

Communication Requirement
The program includes a Communication Requirement of 4 subjects:
- 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and
- 2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

Required Subjects
- 9.00 Introduction to Psychological Science, 12, HASS-S
- 9.01 Introduction to Neuroscience, 12, REST; Physics II (GIR)*
- 9.06 Quantitative Methods for Brain and Cognitive Sciences, 12; 9.01, Calculus II (GIR)*
- 9.07 Statistics for Brain and Cognitive Science, 12; 9.06*
or
- 9.05 Introduction to Probability and Statistics, 12, REST; Calculus II (GIR)

6.00 Introduction to Computer Science and Programming, 12, REST

Core Subjects
Choose five subjects from three areas: cognitive science, cognitive neuroscience, and neuroscience.
Any combination of subjects is permitted, but at least one subject must be chosen in a second area.

Cognitive Science
9.34 Sensory and Social Orders, 9; 9.00*
9.37J Anigrafs, 9; 9.35*
9.56J Abnormal Language, 12; 24.900*
9.57J Language Acquisition, 12, HASS-S; 24.900*
9.65 Cognitive Processes, 12, HASS-S; 9.00
9.66J Computational Cognitive Science, 12; 9.07*
9.85 Computational Cognitive Science, 12, HASS-S, CI-M; 9.00
24.900 Introduction to Linguistics, 12, HASS-ST, CI-H

Cognitive Neuroscience
9.10 Behavioral Neuroscience, 12; 9.01
9.20 Animal Behavior, 12, HASS-S; 9.00*
9.35 Sensation and Perception, 12; 9.00, 9.07*
9.71 Functional MRI Investigations of the Human Brain, 12, CI-M; 9.07, 9.34*

Neuroscience
9.03 Neural Basis of Learning and Memory, 12; 9.01
9.04 Neural Basis of Vision and Audition, 12; 9.01*
9.29J Cellular Neurobiology, 12; 7.05
9.34 Brain Structure and its Origins, 12, 9.01
9.35 Biochemistry and Pharmacology of Synaptic Transmission, 12; 9.01*
9.18J Developmental Neurobiology, 12, CI-M; 9.01*
9.29J Introduction to Computational Neuroscience, 12; 18.03, Physics II (GIR); or permission of instructor
9.31 Cell and Systems Neurophysiology, 12; 9.01

Laboratory
One of the following is required:
- 9.02 Systems Neuroscience Laboratory, 12, LAB, CI-M; 9.01, 18.07*
- 9.12 Experimental Molecular Neurobiology, 12, LAB, CI-M; 9.01, Biology (GIR)
- 9.39J Laboratory in Psycholinguistics, 12, LAB, CI-M; 9.00*
- 9.61 Laboratory in Higher-Level Cognition, 12, LAB, CI-M; 9.07, 9.35*
plus one of the following:
- 9.URG Undergraduate Research, 12
- 9.02 Systems Neuroscience Laboratory, 12, LAB, CI-M; 9.01, 18.07*
- 9.12 Experimental Molecular Neurobiology, 12, LAB, CI-M; 9.01, Biology (GIR)
- 9.41 Research and Communication in Neuroscience and Cognitive Science, 18, CI-M; 9.URG, permission of instructor
GRADUATE STUDY

The Department of Brain and Cognitive Sciences offers programs of study leading to the doctoral degree in neuroscience or cognitive science. Areas of research specialization include cellular and molecular neuroscience, systems neuroscience, computation, and cognitive science. The graduate programs are designed to prepare participants to teach and to do original research.

Doctor of Philosophy

The departmental PhD program can normally be completed with four to six years of full-time work, including summers. Institute requirements for the PhD are given in the section on General Degree Requirements under Graduate Education in Part 1. Formal coursework, described below, is intended to prepare the student to pass the general examinations and do original thesis research. The written general examinations will be due in August of the second year.

All students start with a first-term intensive core subject that provides an introduction to brain and behavioral studies from the viewpoint of systems neuroscience. In the fall and/or spring term, students may choose between two core subjects: a two-term core subject covering molecular and cellular neuroscience or a one-term core subject covering cognitive science. Incoming graduate students are encouraged to take all three within the first two years of study. Further coursework will be diversified to give each individual the appropriate background for research in his or her own area.

Coursework in cellular and molecular neuroscience emphasizes the current genetic, molecular, and cellular approaches to biological systems that are necessary to generate advances in neuroscience.

Training in systems neuroscience covers neuroanatomy, neurophysiology, and neurotransmitter chemistry, concentrating on the major sensory and motor systems in the vertebrate brain. Specific ties to molecular neurobiology or computation may be emphasized, depending upon the research interests of the student.

Coursework for students in computation is intended to give both an understanding of empirical approaches to the study of the vertebrate brain and animal behavior and a theoretical background for analyzing computational aspects of biological information processing.

Candidates studying cognitive science take coursework covering such topics as language processing, language acquisition, cognitive development, natural computation, neural networks, connectionist models, and visual information processing. Students also choose seminars and coursework in linguistics, philosophy, logic, mathematics, or computer science, depending on the individual student’s research program.

Graduate students begin a research apprenticeship immediately upon arrival with lab rotations in the first year, after which time advisor assignments are made based upon a match of interests. These assignments may change as a student’s goals become more focused. At the end of the first year, an advisory committee of two to four faculty members is formed. This committee monitors progress and, with membership changing as necessary, evolves into the thesis committee. Thesis research normally requires 24–36 months of full-time activity after the qualifying examinations have been passed. It is expected that the research embodied in the PhD dissertation be original and significant work, publishable in scientific journals.

Assistantships and Fellowships

Financial assistance is provided to qualified applicants in the form of traineeships, research assistantships, teaching assistantships, and a limited number of fellowships, subject to availability of funds. Prospective students are encouraged to apply for individual fellowships such as those sponsored by the National Science Foundation and the National Defense Science and Engineering Graduate Fellowship Program to cover all or part of the cost of their education. The department’s financial resources for non-US citizens are limited; international students are strongly encouraged to seek financial assistance for all or part of the cost of their education from non-MIT sources.

Inquiries

For additional information regarding teaching and research programs, contact the Graduate Office, Department of Brain and Cognitive Sciences, Room 4-2005, 617-253-7403, or visit http://web.mit.edu/grad/.
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Thomas Byrne, MD

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**Principal Research Scientist**  
Ruth Rosenholtz, PhD

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Nelson Yuan-Sheng Kiang  
Eaton-Peabody Professor, Health Sciences and Technology, Brain and Cognitive Sciences, Emeritus

Richard Jay Wurtman, MD  
Cecil H. Green Distinguished Professor of Neuropharmacology, Emeritus
Chemistry is the study of the nanoworld, the world of atoms and molecules spanning dimensions from one to several thousand angstroms. Chemists study the architecture of this miniature universe, explore the changes that occur, unravel the principles that govern these chemical changes, and devise ways to create entirely new compounds and materials. Past triumphs of chemistry include the synthesis of pharmaceuticals and agricultural products, while current challenges include chemical memory, solar cells, superconductors, clean fuels, batteries, and the solution of numerous important problems relating to health and the environment.

The Department of Chemistry offers the Bachelor of Science, Doctor of Philosophy, and Doctor of Science degrees. The department’s program of teaching and research spans the breadth of chemistry. General areas covered include biological chemistry, inorganic chemistry, organic chemistry, and physical chemistry. Some of the research activities of the department, especially those that involve “translation” (the application of basic science to practical problems) are carried out in association with the work of interdisciplinary laboratories and centers. These interdepartmental units include the Center for Materials Science and Engineering, the Francis Bitter Magnet Laboratory, the Harvard-MIT Division of Health Sciences and Technology, the Institute for Medical Engineering and Science, the Institute for Soldier Nanotechnologies, the MIT Energy Initiative, the Center for Environmental Health Sciences, the Koch Institute for Integrative Cancer Research, and the Spectroscopy Laboratory. See Interdisciplinary Research and Study in Part 3 for more information.

The undergraduate program aims to provide rigorous education in the fundamental areas of chemical and biochemical knowledge and experimentation. Undergraduate students are encouraged to participate in the Undergraduate Research Opportunities Program (UROP) and to take graduate-level chemistry classes as well as subjects in other departments at the Institute, Harvard, or Wellesley.

The Department of Chemistry graduate program admits applicants for the Doctor of Philosophy or Doctor of Science degree. In addition to formal coursework, each student undertakes a research problem that forms the core of graduate work. Graduate- and postgraduate-level research is often carried out in collaboration with scientists in other facilities and interdisciplinary laboratories.

For more information, visit http://web.mit.edu/chemistry/www/.

**UNDERGRADUATE STUDY**

**Bachelor of Science in Chemistry/ Course 5**

The Department of Chemistry offers an undergraduate program sufficiently flexible in its electives to provide excellent preparation for careers in many different areas of chemistry. Course 5 is designed to provide an education based on science both for those who intend to go on to graduate study and for those who intend immediately to pursue a professional career in either chemistry or an allied field in which a sound knowledge of chemistry is important. Students receive thorough instruction in the principles of chemistry, supplemented by a strong foundation in mathematics, physics, biology, and the humanities. A Certification in Biochemistry by the American Chemical Society can be received with a bachelor’s degree for students interested in concentrating in this area. The Department of Chemistry also teaches courses jointly with the departments of Biology, Chemical Engineering, and Biological Engineering.

Unrestricted electives allow 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 that give them more detailed knowledge in the areas in which they wish to specialize. Students who plan to enter industry may elect subjects that offer the fundamentals in a selected field of science, engineering, or the humanities and social sciences. Programs may also be elected that lead to a double major in two fields of specialization.

The student’s faculty advisor can offer suggestions for elective subjects that are of value in preparation for specialization in the various broad areas of chemistry. The proper choice of electives is particularly important for students planning to continue their education in a graduate school.

Students at all levels are encouraged to undertake original research under the supervision of a member of the chemistry faculty, and students carrying out research over at least three semesters have the option of preparing an undergraduate thesis.

**Minor in Chemistry**

The requirements for a Minor in Chemistry are as follows:

- 5.03 Principles of Inorganic Chemistry I
- 5.12 Organic Chemistry I
- 5.310 Laboratory Chemistry
- 5.60 Thermodynamics and Kinetics

*Two additional subjects from the following:*

- 5.04 Principles of Inorganic Chemistry II
- 5.07 Biological Chemistry I
- 5.08 Biological Chemistry II
- 5.13 Organic Chemistry II
- 5.36 Biochemistry and Organic Laboratory
- 5.36U* Biochemistry and Organic Laboratory
- 5.37 Organic and Inorganic Laboratory
- 5.37U* Advanced Organic Chemistry
- 5.61 Physical Chemistry
- 5.62 Physical Chemistry

For a general description of the minor program, see Undergraduate Education in Part 1.

**Inquiries**

Additional information may be obtained from the Chemistry Education Office, Room 2-204, 617-253-7271.

**GRADUATE STUDY**

The Department of Chemistry offers the Doctor of Philosophy and Doctor of Science degrees.

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 that forms the core of graduate work. Through the experience of conducting an investigation leading to a doctoral thesis, a student learns general meth-

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*Students may complete 12 units from any combination of the modules in 5.36U and 5.37U (counted as one subject).*
Bachelor of Science in Chemistry/Course 5

General Institute Requirements (GIRs)

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Units</th>
</tr>
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<tbody>
<tr>
<td>Science Requirement [one subject can be satisfied by 5.111 or 5.112 in the Departmental Program]¹</td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>8</td>
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<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement [one subject can be satisfied by 5.12, 5.60, or 5.61 in the Departmental Program]</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement [can be satisfied by completing all three modules in 5.35 in the Departmental Program]</td>
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</table>

Total GIR Subjects Required for SB Degree: 17

Communication Requirement

The program includes a Communication Requirement of 4 subjects:

- 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H);
- 2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program

| Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics). |
|                                                                                                            |
| Required Subjects                                                                                              | Units     |
| 5.03 Principles of Inorganic Chemistry I, 12; 5.12                                                            | 132       |
| 5.09 Principles of Organic Chemistry I, 12, REST; 5.12                                                        |           |
| 5.11 Principles of Chemical Science.¹²                       | 12        |
| 5.12 Organic Chemistry I, 12, REST; Chemistry (GIR)                                                          |           |
| 5.13 Organic Chemistry II, 12; 5.12                                                                           |           |
| 5.35 Introduction to Experimental Chemistry, 12, LAB; Chemistry (GIR)                                        |           |
| Module 1 Survey of Spectroscopy, 4                                                                            |           |
| Module 2 Inorganic Synthesis and Kinetics, 4; Module 1                                                        |           |
| Module 3 Polymeric Light Emitting Devices, 4; 5.12, Module 2                                                  |           |
| 5.36 Biochemistry and Organic Laboratory, 12, CI-M                                                           |           |
| Module 4 Expression and Purification of Enzyme Mutants, 4; 5.07 or 7.05; Module 2 or 5.310; Module 5          |           |
| Module 5 Kinetics of Enzyme Inhibition, 4; 5.07 or 7.05; Module 2 or 5.310; Module 4                          |           |
| Module 6 Organic Structure Determination, 4; 5.12; Module 2 or 5.310; 5.13                                    |           |
| 5.37 Organic and Inorganic Laboratory, 12                                                                  |           |
| Module 7 Introduction to Organic Synthesis, 4; 5.13, Module 6                                                 |           |
| Module 8 Two-Electron Bond, 4; 5.03, Module 6, 5.61                                                           |           |
| Module 9 Dinitrogen Cleavage, 4; 5.03, Module 6, 5.61                                                          |           |
| 5.38 Physical Chemistry Laboratory, 12, CI-M                                                                |           |
| Module 10 Quantum Dots, 4; 5.61, Module 6                                                                     |           |
| Module 11 Time Resolved Molecular Spectroscopy, 4; 5.61; 5.07 or 7.05; Module 5                               |           |
| Module 12 Solid State NMR, 4; 5.61, 5.07 or 7.05; Module 6                                                    |           |
| 5.60 Thermodynamics and Kinetics, 12, REST; Calculus II (GIR), Chemistry (GIR)                              |           |
| 5.61 Physical Chemistry, 12, REST; Physics II (GIR), Calculus II (GIR), Chemistry (GIR)                     |           |
| Restricted Electives                                                                                           | 24        |
| At least two of the following four subjects:                                                                  |           |
| 5.04 Principles of Inorganic Chemistry II, 12; 5.03                                                           |           |
| 5.08 Biological Chemistry II, 12; 5.12; 5.07 or 7.05                                                          |           |
| 5.43 Advanced Organic Chemistry, 12; 5.13                                                                     |           |
| 5.62 Physical Chemistry, 12; 5.60, 5.61                                                                       |           |

Department Program Units That Also Satisfy the GIRs

<table>
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<th>(36)¹²</th>
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</thead>
</table>

Unrestricted Electives

| 60 |

Total Units Beyond the GIRs Required for SB Degree: 180

No subject can be counted both as part of the 17-subject GIRs and as part of the 180 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

Notes

¹An alternate subject is listed in the GIR description.

²Students who do not take 5.111 or 5.112 to fulfill the General Institute Requirement in Chemistry will have 24 units in the Departmental Program that will also satisfy the General Institute Requirements.

For an explanation of credit units, or hours, please refer to the online help of the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.

Entrance Requirements for Graduate Study

Students intending to pursue graduate work in the Chemistry Department should have excellent undergraduate preparation in chemistry. The department is flexible with respect to specific course preparation; the essential requirement is demonstration of ability to progress with advanced study and research in some area of special interest. However, mathematics and physics are important prerequisites for graduate work in physical chemistry or chemical physics, whereas less preparation in these areas is required for work in organic chemistry.

Applicants to the Chemistry Department are required to submit scores from the verbal and quantitative sections of the Graduate Record Examination. Scores on the advanced examinations are optional.

During the first term of residence, all graduate students are encouraged to select research supervisors who serve as advisors for the balance of their graduate careers. In particular, the overall 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.
Doctor of Philosophy and Doctor of Science

The Chemistry 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 that is pertinent to long-range research interests. All students are required to serve as a teaching assistant for two terms, usually during the first year.

Written major examinations are cumulative. Separate examinations in biological, inorganic, organic, and physical chemistry are offered each month from October through May. The examinations demonstrate an understanding of the important principles of each field. Six 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 generally in the fourth term of residence. Progress in the student’s research is also examined at that time. A final oral presentation on the subject of the doctoral research is scheduled after the thesis has been submitted and evaluated by a committee of examiners.

Teaching and Research Assistantships

The department usually appoints first-year graduate students as teaching assistants (TAs). TAs are assigned either to laboratory subjects or to discussion sections of lecture subjects. Most students receive appointments to research assistantships after their first year, and departmental fellowships are also available. Financial support after the first academic year is subject to the availability of funds and provided for students who maintain a satisfactory record.

Inquiries

Correspondence about the graduate program or appointments should be addressed to the Chemistry Graduate Office, Room 2-204, 617-253-1845.

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Faculty and Teaching Staff

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Randy Scanga, BS
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John Stewart Waugh, PhD
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Professor of Chemistry, Emeritus

Gerald Norman Wogan, PhD
Professor of Chemistry, Emeritus
The Department of Earth, Atmospheric, and Planetary Sciences offers the bachelor’s degree in earth, atmospheric, and planetary sciences, and master’s and doctoral degrees in earth and planetary sciences, atmospheric sciences, oceanography, and climate physics and chemistry.

Departmental programs apply physics, chemistry, and mathematics to the study of the Earth and planets in order to understand the processes that are active in the Earth’s interior, oceans, and atmosphere, as well as the interiors and atmospheres of other planets. The department also uses the basic sciences to understand the past history of the Earth and planets. By combining the past history with models of present physical and chemical processes, faculty and students work to develop an understanding of the dynamics of systems as diverse as the global climate system, regional tectonics and deformation, petroleum and geothermal reservoirs, and the solar system.

Department faculty members teach and carry out research through programs in atmospheres, oceans and climate, geochemistry, geology, geobiology, geophysics, and planetary science. Specific research activities include environmental earth science, global climate change science, planetary missions, and earthquake and exploration geophysics.

Modern problems in these fields are approached by field measurements, laboratory studies, and theory. Experimental facilities for training and research are available not only in departmental laboratories such as the Earth Resources Laboratory, but also in MIT’s interdepartmental laboratories such as the Center for Global Change Science, Kavli Institute for Astrophysics and Space Research, Haystack Radio Observatory and Millstone Radar facility, and the Wallace Astrophysical and Geophysical Observatories (described in the section on Interdisciplinary Research and Study in Part 3), and in cooperating institutions such as the Woods Hole Oceanographic Institution.

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### Bachelor of Science in Earth, Atmospheric, and Planetary Sciences/ Course 12

#### General Institute Requirements (GIRs)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>8</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>2</td>
</tr>
</tbody>
</table>

#### Laboratory Requirement

- Calculus II (GIR)

#### Total GIR Subjects Required for SB Degree

- 17

#### Communication Requirement

The program includes a Communication Requirement of 4 subjects:

- 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and
- 2 subjects designated as Communication Intensive in the Major (CI-M).

#### PLUS Departmental Program

- Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

#### Required Subjects

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.002</td>
<td>Essentials of Geology</td>
<td>12</td>
<td>Calculus II (GIR)</td>
</tr>
<tr>
<td>12.003</td>
<td>Physics of the Atmosphere and Ocean</td>
<td>12</td>
<td>REST; Physics I (GIR), Calculus II (GIR)</td>
</tr>
<tr>
<td>12.009</td>
<td>Theoretical Environmental Analysis</td>
<td>12</td>
<td>Physics I (GIR); 18.03</td>
</tr>
<tr>
<td>18.03</td>
<td>Differential Equations</td>
<td>12</td>
<td>REST; Calculus II (GIR)</td>
</tr>
<tr>
<td>18.034</td>
<td>Differential Equations</td>
<td>12</td>
<td>REST; Calculus II (GIR)</td>
</tr>
<tr>
<td>12.TIP</td>
<td>Thesis and Independent Study Preparation</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>12.THU</td>
<td>Undergraduate Thesis (at least 6 units)</td>
<td>6</td>
<td>CI-M; 12.TIP</td>
</tr>
</tbody>
</table>

#### Laboratory/Field Subjects:

- One of the following:
- 12.113 Field Geology II, 12, LAB, CI-M; 12.114
- 12.221 Field Geophysics, 6
- and 12.223 Field Geophysics Analysis, 6, CI-M; 12.221
- 12.307 Weather and Climate Laboratory, 12, LAB, CI-M; Calculus II (GIR), Physics I (GIR)
- 12.335 Experimental Atmospheric Chemistry, 12, LAB, CI-M; Chemistry (GIR)
- 12.410 Observational Techniques of Optical Astronomy, 15, LAB, CI-M; 8.282*; 8.03
- 12.115 Field Geology I, 12, LAB, CI-M; 12.113
- 12.222 Field Geophysics, 6, CI-M; 12.221
- 12.307 Weather and Climate Laboratory, 12, LAB, CI-M; Calculus II (GIR), Physics I (GIR)
- 12.335 Experimental Atmospheric Chemistry, 12, LAB, CI-M; Chemistry (GIR)
- 12.410 Observational Techniques of Optical Astronomy, 15, LAB, CI-M; 8.282*; 8.03
- 12.115 Field Geology I, 12, LAB, CI-M; 12.113
- 12.222 Field Geophysics, 6, CI-M; 12.221

The remainder of the program consists of 72 units from either the Discipline or Supporting Science subjects; no more than 48 units can be from Supporting Science. The program of study must be approved by the student’s academic advisor and the undergraduate committee of the department.

#### Discipline Subjects

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.002</td>
<td>Physics of the Terrestrial Planets</td>
<td>12</td>
</tr>
<tr>
<td>12.009</td>
<td>Applications of Continuum Mechanics to Earth, Atmospheric, and Planetary Sciences</td>
<td>12</td>
</tr>
<tr>
<td>12.006</td>
<td>Nonlinear Dynamics I: Chaos</td>
<td>12</td>
</tr>
<tr>
<td>12.007</td>
<td>Geobiology: History of Life on Earth</td>
<td>12</td>
</tr>
<tr>
<td>12.008</td>
<td>Classical Mechanics: A Computational Approach</td>
<td>12</td>
</tr>
<tr>
<td>12.012</td>
<td>Modeling Environmental Complexity</td>
<td>12</td>
</tr>
<tr>
<td>12.013</td>
<td>Environmental Earth Science</td>
<td>12</td>
</tr>
<tr>
<td>12.014</td>
<td>Geological and Geophysical Techniques</td>
<td>12</td>
</tr>
<tr>
<td>12.015</td>
<td>Structure of Earth Materials</td>
<td>12</td>
</tr>
<tr>
<td>12.016</td>
<td>Structural Geology</td>
<td>12</td>
</tr>
<tr>
<td>12.017</td>
<td>Field Geology I</td>
<td>6</td>
</tr>
<tr>
<td>12.012</td>
<td>Environmental Earth Science Field Course</td>
<td>6</td>
</tr>
<tr>
<td>12.158</td>
<td>Molecular Biogeography</td>
<td>9</td>
</tr>
<tr>
<td>12.163</td>
<td>Geomorphology</td>
<td>12</td>
</tr>
<tr>
<td>12.164</td>
<td>Essentials of Geology</td>
<td>12</td>
</tr>
<tr>
<td>12.201</td>
<td>Essentials of Geophysics</td>
<td>12</td>
</tr>
<tr>
<td>12.207</td>
<td>Nonlinear Dynamics II: Continuum Systems</td>
<td>12</td>
</tr>
<tr>
<td>12.213</td>
<td>Alternate Energy Sources</td>
<td>6</td>
</tr>
<tr>
<td>12.214</td>
<td>Environmental Geophysics</td>
<td>12</td>
</tr>
<tr>
<td>12.301</td>
<td>Past and Present Climate</td>
<td>12</td>
</tr>
</tbody>
</table>

*CI-H: Communication Intensive in Humanities; CI-M: Communication Intensive in the Major
12.310 An Introduction to Weather Forecasting, 6; Physics I (GIR), Calculus I (GIR)
12.333 Atmospheric and Ocean Circulations, 12; 12.003
12.340 Global Warming Science, 12; Physics I (GIR)*, 5.60
12.348 Global Climate Change: Economics, Science, and Policy, 9; Calculus II (GIR), 5.60, 14.01*; or permission of instructor
12.420 Physics and Chemistry of the Solar System, 12; 12.002*
12.425 Extrasolar Planets: Physics and Detection Techniques, 12, REST; Physics I (GIR), Calculus I (GIR)
12.431 Space Systems Engineering, 12; permission of department
12.433j Space Systems Development I, 12; LAB; 16.83j

Supporting Science Subjects
1.00 Introduction to Computers and Engineering Problem Solving, 12; Calculus I (GIR)
1.065 Engineering Mechanics II, 12; permission of instructor*
1.066 Transport Processes in the Environment, 12; 1.060; 1.106, 1.070; or permission of instructor
1.080 Environmental Chemistry and Biology, 12; Chemistry (GIR), Biology (GIR)
3.012 Fundamentals of Materials Science and Engineering, 15, REST; 18.03*
or
5.60 Thermodynamics and Kinetics, 12, REST; Calculus II (GIR), Chemistry (GIR)
5.07 Principles of Inorganic Chemistry I, 12; 5.12
5.12 Organic Chemistry I, 12, REST; Chemistry (GIR)
5.6a Physical Chemistry, 12; REST; Physics II (GIR), Calculus II (GIR), Chemistry (GIR)
6.00 Introduction to Computer Science and Programming, 12, REST
7.03 Genetics,12, REST; Biology (GIR)
7.05 General Biochemistry, 12, REST; 5.12*
7.11 Microbial Physiology, 12; 7.03, 7.05
8.03 Physics III, 12, REST; Physics II (GIR), Calculus II (GIR)
8.04 Quantum Physics I, 12, REST; 8.03*, 18.03*
8.045 Statistical Physics I, 12; 8.03, 18.03
8.05 Electromagnetism II, 12; 8.03, 18.03
8.09 Classical Mechanics III, 12; Physics I (GIR)
8.21 Physics of Energy, 12, REST; Physics II (GIR), Calculus II (GIR), Chemistry (GIR)
12.010 Computational Methods of Scientific Programming, 12; Calculus II (GIR), Physics I (GIR)
12.320 Introductions to Hydrology, 12; 1.060, 1.061, 1.106
18.04 Complex Variables with Applications, 12, Calculus II (GIR), 18.03*
18.05 Introduction to Probability and Statistics, 12, REST; Calculus I (GIR)
18.06 Linear Algebra, 12, REST; Calculus II (GIR)
18.100 Real Analysis I, 12; Calculus II (GIR), 18.03*
18.31 Principles of Applied Mathematics, 12; Calculus II (GIR), 18.03*

Students with appropriate interests may substitute two subjects in urban planning, economics, policy, or management for subjects in the Supporting Science category.

Departmental Program Units That Also Satisfy the GIRs

<table>
<thead>
<tr>
<th>Subject</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to Weather Forecasting</td>
<td>6</td>
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<tr>
<td>Atmospheric and Ocean Circulations</td>
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</tr>
<tr>
<td>Global Warming Science</td>
<td>12</td>
</tr>
<tr>
<td>Global Climate Change: Economics, Science, and Policy</td>
<td>9</td>
</tr>
<tr>
<td>Environmental Chemistry and Biology</td>
<td>12</td>
</tr>
<tr>
<td>Materials Science and Engineering</td>
<td>15</td>
</tr>
<tr>
<td>Thermodynamics and Kinetics</td>
<td>12</td>
</tr>
<tr>
<td>Principles of Inorganic Chemistry I</td>
<td>12</td>
</tr>
<tr>
<td>Organic Chemistry I</td>
<td>12</td>
</tr>
<tr>
<td>Physical Chemistry</td>
<td>12</td>
</tr>
<tr>
<td>Introduction to Computer Science and Programming</td>
<td>12</td>
</tr>
<tr>
<td>General Biochemistry</td>
<td>12</td>
</tr>
<tr>
<td>Microbial Physiology</td>
<td>12</td>
</tr>
<tr>
<td>Physics III</td>
<td>12</td>
</tr>
<tr>
<td>Quantum Physics I</td>
<td>12</td>
</tr>
<tr>
<td>Statistical Physics I</td>
<td>12</td>
</tr>
<tr>
<td>Electromagnetism II</td>
<td>12</td>
</tr>
<tr>
<td>Classical Mechanics III</td>
<td>12</td>
</tr>
<tr>
<td>Physics of Energy</td>
<td>12</td>
</tr>
<tr>
<td>Computational Methods of Scientific Programming</td>
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<tr>
<td>Introduction to Hydrology</td>
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<tr>
<td>Complex Variables with Applications</td>
<td>12</td>
</tr>
<tr>
<td>Introduction to Probability and Statistics</td>
<td>12</td>
</tr>
<tr>
<td>Linear Algebra</td>
<td>12</td>
</tr>
<tr>
<td>Real Analysis I</td>
<td>12</td>
</tr>
<tr>
<td>Principles of Applied Mathematics</td>
<td>12</td>
</tr>
</tbody>
</table>

Total Units Beyond the GIRs Required for SB Degree 180

No subject can be counted both as part of the 17-subject GIRs and as part of the 180 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

Notes
*Alternate prerequisites and corequisites are listed in the subject description.
For an explanation of credit units, or hours, please refer to the online help in the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.

UNDERGRADUATE STUDY

Bachelor of Science in Earth, Atmospheric, and Planetary Sciences/Course 12

The Earth, Atmospheric, and Planetary Sciences Department offers undergraduate preparation for professional careers in a wide range of fields in geoscience (which includes geology, geophysics, and geochemistry), physics of atmospheres and oceans, environmental science, and planetary science and planetary astronomy. Students concentrate in one of these four areas.

The curriculum for the Bachelor of Science in Earth, Atmospheric, and Planetary Sciences ensures a fundamental background through departmental core subjects and advanced study in an area of concentration that includes required subjects and restricted electives. Students are also required to take field and/or laboratory subjects, and to complete an independent research project as part of the degree requirements.

Double Major

Studies in physics, chemistry, biology, applied mathematics, and electrical or civil engineering are directly relevant preparation for work in earth, atmospheric, and planetary sciences. Students from these departments can arrange a program of study in Course 12 leading to a second major in one of the department’s areas of concentration.

Five-Year Program

Students with strong academic records from the departments of Earth, Atmospheric, and Planetary Sciences, Chemistry, Physics, Mathematics, Civil and Environmental Engineering, Electrical Engineering and Computer Science, or Chemical Engineering, should be able to complete a Master of Science in Earth and Planetary Sciences, in Atmospheric Sciences, or in Ocean Sciences in one year of additional study, particularly if 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. 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.
Minors
The requirements for the Minor in Earth, Atmospheric, and Planetary Sciences are as follows:

Core Subjects
Two subjects from:
12.001 Introduction to Geology
12.002 Physics and Chemistry of the Terrestrial Planets
12.003 Physics of the Atmosphere and Ocean
12.006 Nonlinear Dynamics I: Chaos
12.102 Environmental Earth Science
12.400 The Solar System

One subject from:
18.03/18.034 Differential Equations
5.60 Thermodynamics and Kinetics

Restricted Electives
Two or more additional Course 12 subjects within one of the EAPS concentration areas, approved by the minor advisor; and 12 units from the following:
Lab: 12.115, 12.119, 12.307, 12.410
Field and IAP: 12.120, 12.141, 12.213, 12.214, 12.221, 12.310, 12.411
Independent Study: 12.IND, 12.UR

The Earth, Atmospheric, and Planetary Sciences Department jointly offers a Minor in Astronomy with the Department of Physics (Course 8). A detailed description and list of requirements for this minor is available in the Interdisciplinary Undergraduate Programs and Minors section in Part 3.

Inquiries
Additional information may be obtained from the department’s Education Office, Room 54-912, 617-253-3381.

GRADUATE STUDY
The Department of Earth, Atmospheric, and Planetary Sciences offers opportunities for graduate study and research in a wide range of fields, as indicated by the detailed subject descriptions in the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi. This course work is the usual prelude to a thesis demonstrating that the student is capable of independent and creative research. A successful thesis leads to a graduate degree: a Master of Science, a Doctor of Philosophy, or a Doctor of Science in the field of specialization.

A graduate thesis may have either a theoretical, experimental, or observational focus. Modern laboratory facilities, computers, instrumentation, and extensive collections of specimens and data are available to students. Field study is an essential part of the graduate curriculum in geology, geophysics, and geochemistry, and special arrangements may be made for summer employment and field research on departmental projects and with industrial organizations and government agencies. In oceanography, sea-going observational research is an important part of the educational experience. In atmospheric science, climate studies, and oceanography, graduate study includes a mixture of theoretical and experimental studies sharing a common appreciation of the dynamics of the underlying processes.

Entrance Requirements for Graduate Study
In addition to the general institute requirements for admission listed in the section on Graduate Education in Part 1, the department requires preparation equivalent to the curriculum for the Bachelor of Science in Earth, Atmospheric, and Planetary Sciences at MIT for graduate studies in that field. For atmospheric sciences, climate studies, meteorology, and oceanography, the most essential element is a sound preparation in mathematics and physics, supplemented if possible by some chemistry. Students taking their undergraduate work at other institutions are advised to include in their programs the equivalent of the mathematics and physics contained in the MIT undergraduate curricula. If students are not fully prepared in certain of the fields or required subjects, they usually are asked to extend their studies in these areas while pursuing advanced work. The doctoral program can be entered without a Master of Science as a prerequisite.

Joint Program with the Woods Hole Oceanographic Institution
MIT and WHOI have established a program in oceanography that leads to a jointly awarded degree of Master of Science, Doctor of Philosophy, or Doctor of Science. For more information, see the program description at the end of Part 3.

Master of Science in Earth and Planetary Sciences, in Atmospheric Science, or in Climate Physics and Chemistry
The General Degree Requirements for the degree of Master of Science in Earth and Planetary Science, in Atmospheric Science, or in Climate Physics and Chemistry are described under Graduate Education in Part 1. An individual program of study and research is arranged to suit the special background, needs, and goals of each student. The program is worked out in detail by the student with his or her personal faculty advisor and a departmental committee. There are no foreign language requirements for the degree. Master’s students in climate and atmospheric science have access to the facilities of the joint MIT-WHOI program.

Doctor of Philosophy and Doctor of Science
General Degree Requirements for the degree of Doctor of Philosophy or Doctor of Science are given in the section on Graduate Education in Part 1. The department does not require candidates for the doctorate to present evidence of competence in a foreign language, but it strongly urges that candidates for the doctorate acquire intermediate competence in one or more languages. A specialized program of study and research is tailored to each student’s background, needs, and goals by the student in consultation with a faculty advisor and a departmental committee. A doctoral candidate’s program should be broad and include formal study in other departments in addition to the specialized subjects that prepare the candidate for thesis research. Thesis research normally begins immediately after successful completion of the general examination by the end of the second year. The general examination is intended to test the candidate’s aptitude and preparation for independent research.

Thesis research is closely supervised by one or more faculty members interested in and knowledgeable about the research topic, who are chosen by the student and may be members of other departments. The thesis is expected to meet high professional standards, and to be a significant original contribution to the scientific field.
Teaching and Research Assistantships
The department offers a considerable number of research and teaching assistantships each year. Research assistants work on one of the many research projects in the department, often related to the student’s thesis research. Teaching assistants assist in laboratory instruction or in the preparation of teaching materials and the grading of papers.

The department also offers several fellowships beyond normal teaching and research assistantships. Selection of individuals is based on the excellence of the applicant’s record.

Inquiries
Additional information regarding academic and current research programs in the department, admission requirements, assistantship appointments, and financial aid may be obtained by writing to the department’s Education Office, Room 54-912, 617-253-3381.

RESEARCH LABORATORIES AND PROGRAMS

Earth Resources Laboratory
The Earth Resources Laboratory (ERL) is one of the premier research laboratories in the world in the areas of applied geophysics and quantitative geology. The lab studies the spatial heterogeneity of the earth’s upper crust through geophysical imaging, geological process modeling, and the interactions between rock pore systems and migrating fluids. Laboratory activities are centered around theoretical, experimental, and observational research programs in basic science that have both industrial and academic applications. Research at the lab is supported by industry and government agencies.

ERL’s major research activities include: elastic wave propagation in complex media; characterization of reservoir properties such as fracture density, in-situ stress, and fluid mobility from seismic and well log data; turbidite depositional dynamics; field mapping of reservoir scale geologic analogs in Western Africa; electroseismic phenomena; imaging and simulation of pore-scale fluid flow; borehole acoustics; reservoir imaging from surface and borehole seismic data; GPS measurements of crustal deformation in the Eastern Mediterranean, including the North Anatolian fault system in Turkey; and geophysical monitoring of groundwater contaminant movement.

ERL’s computation environment consists of a large network of workstations and personal computers, as well as the Reservoir Science Visualization Laboratory, which includes a number of high performance workstations running data analysis and visualization software. This facility is used to enhance and expand ERL’s research activities in petroleum reservoir imaging and monitoring, environmental geophysics, and geologic mapping and remote sensing. ERL also has a wide range of experimental facilities and equipment, including a large-scale (5m by 5m) sediment dynamics tank, and Ultrasonic Laboratory for seismic imaging and borehole experiments, and field equipment for seismic, electrical, and GPR surveys.

Further information can be obtained through ERL headquarters, Room 54-1814, or by calling Professor Robert van der Hilst at 617-253-6977.

Center for Global Change Science
The Center for Global Change Science (CGCS) seeks to address long-standing scientific problems that impede our ability to accurately predict changes in the global environment. Established in 1990, CGCS is an interdepartmental organization that conducts research on global climate processes, climate observations, and past climate variations. Participants include faculty, staff, and students from a variety of natural science and engineering disciplines.

The center’s activities also involve substantial multidisciplinary cooperative efforts focused on climate modeling, through the Climate Modeling Initiative (http://pooc.mit.edu/cmi/), and climate-policy research, through the Joint Program on the Science and Policy of Global Change (http://mit.edu/globalchange/).

For further information, see the center description in the section Interdisciplinary Research and Study in Part 3.

Joint Program on the Science and Policy of Global Change
The Joint Program on the Science and Policy of Global Change conducts independent analyses of climate-policy issues and research on climate science. It is a cooperative effort of the Center for Global Change Science and the Center for Energy and Environmental Policy Research that brings together natural and social scientists to address global environmental change and human-climate interaction. The program is a highly visible and well-funded effort, providing rigorous integrated assessment of the climate change issue to governments, industry, and the public. The cornerstone of the program’s research is an interacting set of models of the world economy (human activities) and the earth system (coupled ocean, atmosphere, land, and ecosystems). The program cooperates closely with the Ecosystems Center of the Marine Biological Laboratory in Woods Hole, MA; the MIT Climate Modeling Initiative; and other MIT environmental programs.

For further information see the program description in the section Interdisciplinary Research and Study in Part 3.

George R. Wallace, Jr. Astrophysical Observatory
The George R. Wallace, Jr., Astrophysical Observatory is a versatile facility for research and teaching optical astronomy. The observatory located in Westford, MA, has two optical telescopes with 16-inch and 24-inch diameters and unique electronic instrumentation. The telescopes are used in formal instruction for student research projects, and as testbeds for instrumentation to be used with larger telescopes.

Further information on the Wallace Observatory may be obtained by contacting Professor James L. Elliot, Room 54-422, 617-253-6308, jle@mit.edu, or visit http://web.mit.edu/wallace/.

Wallace Geophysical Observatory
The George R. Wallace, Jr., Geophysical Observatory is a unique research facility designed to monitor ground motions and to aid in the development and testing of new seismic and other geophysical instrumentation. It is also a key component of MIT’s five-station seismic network in New England.

Located 35 miles north of Boston in Westford, MA, the observatory has a large, multi-room underground vault and a surface control room. The vault has a controlled temperature environment and instrument piers resting directly on the basement granite. The observatory contains sensitive seismometers and instruments for monitoring ground tilts and the earth’s tidal motions. The surface building houses a work area and control and recording instruments. Data from the observatory are telemetered directly to the Earth Resources Laboratory of the Department of
Earth, Atmospheric, and Planetary Sciences. The data from the observatory and the New England Seismic Network are recorded, displayed, and analyzed by three dedicated COMPAQ computers, which are also connected to workstations to facilitate data sharing and transfers. Data from the observatory along with the numerous resources of the department provide a unique facility for undergraduates, graduate students, and staff to pursue research concerning the interior of the earth.

Further information may be obtained by contacting the director, Professor M. Nafi Toksöz, Room E34-440, 617-253-7852, nafi@erl.mit.edu.

**FACULTY AND STAFF**

**Faculty and Teaching Staff**
Robert van der Hilst, PhD
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Department Head

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Associate Department Head

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Robert R. Shrock Professor of Geology
MacVicar Faculty Fellow

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Director, MIT-WHOI Joint Program

Burrell Clark Burchfiel, PhD
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Kerry Andrew Emanuel, PhD
Cecil & Ida Green Professor

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Ronald George Prinn, ScD
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Director, Center for Global Change Science

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Professor of Geophysics

Leigh H. Royden, PhD
Professor of Geology and Geophysics

Sara Seager, PhD
Class of 1941 Professor
Professor of Physics

Susan Solomon
Ellen Swallow Richards Professor

Roger E. Summons, PhD
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Daniel Cziczo
Assistant Professor of Atmospheric Chemistry

Paul O’Gorman, PhD
Associate Professor of Atmospheric Science

Benjamin P. Weiss, PhD
Associate Professor of Planetary Sciences

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Assistant Professor of Geology

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David McGee, PhD
Assistant Professor of Paleoclimate

Shuhei Ono, PhD
Kerr-McGee Career Development Assistant Professor of Geophysics

Cecil & Ida Green Career Development Assistant Professor of Geomorphology and Planetary Science

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Professor of Geophysics

Martijn V. de Hoop, PhD
Professor of Geophysics

Linda T. Elkins-Tanton, PhD
Professor of Geological Sciences

**Senior Lecturer**
Lodovica Illari, PhD

**Lecturer**
Amanda Bosh, PhD

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**Senior Research Scientists**
William Durham, PhD
Michael Fehler, PhD
Michael Follows, PhD

**Associate Professors**
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Associate Professor of Geobiology
Principal Research Scientists
Nilanjan Chatterjee, PhD
Patrick Heimbach, PhD
Robert W. King, Jr., PhD
Srinivas Ravela, PhD
Robert Reilinger, PhD
William Rodi, PhD

Principal Research Engineer
Christopher Hill, BS

Research Engineer
Zhenya Zhu, PhD

Research Scientists
Eduardo Andrade Lima, PhD
William Bains, PhD
Noah Bechor Ben Dov, PhD
Yves Bernabé, PhD
Daniel Burns, PhD
Jean-Michel Campin, PhD
Christopher Carr, PhD
Stephanie Dutkiewicz, PhD
Ming Fang, PhD
David Ferreira, PhD
Gael Forget, PhD
Helen Hill, PhD
Oliver Jahn, PhD
Sadi Kuleli, PhD
Anthony Leboissetier, PhD
Erwan Mazarico, PhD
Ulrich Mok, PhD
An Nguyen, PhD
Michael Person, PhD
Oleg Poliannikov
Jahandar Ramezani, PhD
Anna Shaughnessy, PhD
Executive Director, Earth Resources Laboratory
David E. Smith, PhD
Jason Soderblom, PhD
Haijian Zhang, PhD
Yingcai Zheng, PhD

Research Specialists
Richard Kayser, MS
Charmaine King, BS
Linda Meinke, BS
William Olszewski, PhD
Diana Spiegel, MS
Yunpeng Wang, PhD

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Sheekela Baker-Yeboah, PhD
Michael Bates, PhD
Robert Buchwaldt, PhD
Gonzalo Carrasco, PhD
Phoebe Cohen, PhD
Elizabeth Day, PhD
Francesca DeMeo, PhD
Bruce-Olivier Demory, PhD
Michael Floyd, PhD
Berenice Fromet, PhD
Thomas Gallot, PhD
Pierre Goudard, PhD
Christian Hallmann, PhD
Yu-Te Hsieh, PhD
Yi-wen Huang, PhD
Eric Leibensperger, PhD
Kristen Miller, PhD
Abigail Noble, PhD
Victor Ocana, PhD
Anne Willem Omta, PhD
Daniel Reeves, PhD
Florence Schubotz, PhD
Julio Sepulveda, PhD
Hansjörg Seybold, PhD
Vlada Stamenkovic, PhD
Clement Suavet, PhD
Ross Tulloch, PhD
Nicholas Van Buer, PhD
Daiwei Wang, PhD
Pengfei Xue, PhD
Da Zhu, PhD
Andras Zsom, PhD

Postdoctoral Fellows
Bernard Charlier, PhD
Aaron Donohoe, PhD
Brian Gertsch, PhD
Daniel Goldberg, PhD
Vincent Jugnon, PhD
Ning Lin, PhD
Harry Oduro, PhD
David Polishook, PhD
Diana Valencia
Sergio Vellina-Fernandez, PhD
Paula Welander, PhD

Research Affiliates
Moshe Alamaro, PhD
Mark Behn, PhD
Thomas Burbine, PhD
Benjamin Crosby, PhD
Zoe Finkel, PhD
Levent Gulen, PhD
John Michael Hayes, PhD
Michael Krawczynski, PhD
Stephen Levine, PhD
Amala Mahadevan, PhD
Scott Miller, PhD
Douglas Miller, PhD
Rui Ponte, PhD
Malcolm Pringle, PhD
Carolyn Seto, PhD
Stephan Silvan, PhD
Margaret Thompson, PhD

Visiting Scientists
Paolo Bergamo, PhD
Stephen Brown, PhD
Kevin Burke, PhD
Carol Anne Clayson, PhD
Ali Dogru, PhD
Sarah Miller, PhD
Dick Reesman, PhD
Carolyn Rupel, PhD
Jing Yao, PhD

Professors Emeriti
Charles Claude Counselman III, PhD
Professor of Planetary Sciences, Emeritus
Frederick August Frey, PhD
Professor of Geochemistry, Emeritus
Richard Siegmund Lindzen, PhD
Professor of Meteorology, Emeritus
Theodore Richard Madden, PhD
Professor of Geophysics, Emeritus
Gordon Hemenway Pettengill, PhD
Professor of Planetary Physics, Emeritus
M. Gene Simmons, PhD
Professor of Geophysics, Emeritus
John Brelsford Southard, PhD
Professor of Geology, Emeritus
Peter Hunter Stone, PhD
Professor of Climate Dynamics, Emeritus
M. Nafi Toksöz, PhD
Professor of Geophysics, Emeritus
The Department of Mathematics offers training at the undergraduate, graduate, and postgraduate levels. Its expertise covers a broad spectrum of fields ranging from the traditional areas of “pure” mathematics, such as analysis, algebra, geometry, and topology, to applied mathematics areas such as combinatorics, computational biology, fluid dynamics, theoretical computer science, and theoretical physics.

Course 18 includes two undergraduate degrees: a Bachelor of Science in Mathematics and a Bachelor of Science in Mathematics with Computer Science. Undergraduate students may choose one of three options leading to the Bachelor of Science in Mathematics: applied mathematics, theoretical mathematics, or general mathematics. The general mathematics option provides a great deal of flexibility and allows students to design their own programs in conjunction with their advisors. The Mathematics with Computer Science degree is offered for students who want to pursue interests in mathematics and theoretical computer science within a single undergraduate program.

At the graduate level, the Mathematics Department offers the PhD in Mathematics, which culminates in the exposition of original research in a dissertation. Graduate students also receive training and gain experience in the teaching of mathematics.

The CLE Moore instructorships and Applied Mathematics instructorships bring mathematicians at the postdoctoral level to MIT and provide them with training in research and teaching.

For more information, visit [http://math.mit.edu](http://math.mit.edu).

**UNDERGRADUATE STUDY**

An undergraduate degree in mathematics provides an excellent basis for graduate work in mathematics or computer science, or for employment in such fields as finance, business, or consulting. Students’ programs are arranged through consultation with their faculty advisors.

Undergraduates in mathematics are encouraged to elect an undergraduate seminar during their junior or senior year. The experience gained from active participation in a seminar conducted by a research mathematician has proven to be valuable for students planning to

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**Bachelor of Science in Mathematics/Course 18**

<table>
<thead>
<tr>
<th>General Institute Requirements (GIRe)</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total GIR Subjects Required for SB Degree</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

**Communication Requirement**
The program includes a Communication Requirement of 4 subjects: 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and 2 subjects designated as Communication Intensive in the Major (CI-M).

**PLUS Departmental Program**
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

<table>
<thead>
<tr>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>One of the following two subjects:</td>
<td>12</td>
</tr>
<tr>
<td>18.03 or 18.034 Differential Equations, 12; Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td><strong>Restricted Electives</strong></td>
<td>96–102</td>
</tr>
<tr>
<td>Students must take at least two CI-M subjects, and two subjects</td>
<td></td>
</tr>
<tr>
<td>from each group:</td>
<td></td>
</tr>
<tr>
<td>One of the following two subjects:</td>
<td></td>
</tr>
<tr>
<td>18.100, 18.304, 18.314, 18.404, 18.424, 18.434, 18.504, 18.704, 18.784,</td>
<td></td>
</tr>
<tr>
<td>18.821, 18.904, or 18.994</td>
<td></td>
</tr>
<tr>
<td>or one from the above list and one of the following subjects: 8.06, 14.33, 18.100C,</td>
<td></td>
</tr>
<tr>
<td>or 18.310.</td>
<td></td>
</tr>
</tbody>
</table>

**General Mathematics Option**

Eight 12-unit subjects of essentially different content, including at least six advanced subjects (first decimal digit one or higher). One of these eight subjects must be 18.06, 18.700, or 18.701.

**Applied Mathematics Option**

18.310A Principles of Discrete Applied Mathematics, 12; Calculus II (GIR) or 18.310 Principles of Discrete Applied Mathematics, 15, CI-M; Calculus II (GIR)

18.311 Principles of Continuum Applied Mathematics, 12; Calculus II (GIR), 18.03*

One of the following two subjects:

18.04 Complex Variables with Applications, 12; Calculus II (GIR), 18.03*

18.112 Functions of a Complex Variable, 12; 18.100, 18.06*

One of the following two subjects:

18.112 Linear Algebra, 12, REST; Calculus II (GIR)

18.700A Linear Algebra, 12, REST; Calculus II (GIR)

Four additional 12-unit Course 18 subjects from the following two groups with at least one subject from each group:

**Group I**—Probability and statistics, combinatorics, computer science

**Group II**—Numerical analysis, physical mathematics, nonlinear dynamics

**Theoretical Mathematics Option**

18.100 Real Analysis, 12; Calculus II (GIR), 18.03*

18.701A Algebra I, 12; 18.701*

18.702 Algebra II, 12; 18.701

18.901 Introduction to Topology, 12; 18.100*

One of the following subjects:

18.101 Analysis and Manifolds, 12; 18.100, 18.06*

18.102 Introduction to Functional Analysis, 12; 18.100, 18.06*

18.103 Fourier Analysis—Theory and Applications, 12; 18.100, 18.06*

An undergraduate seminar from the following list: 18.104, 18.504, 18.704, 18.784, 18.904, 18.994 (12 units).

Two additional 12-unit Course 18 subjects of essentially different content, with the first decimal digit one or higher (24 units)

**Departmental Program Units That Also Satisfy the GIRs** (12)

**Unrestricted Electives**

78–84
Mathematics typically enroll in 18.310 and 18.311 Equilibrium, stability, optimization, computer science. Particular attention is given to the following principles and engineering, and computer science. Many mathematics majors take 18.821 Project Laboratory in Mathematics, which fulfills both the Institute’s Laboratory Requirement and Communication Requirement.

Bachelor of Science in Mathematics/Course 18

General Mathematics Option
In addition to the General Institute Requirements, the requirements consist of 18.03 or 18.034 Differential Equations, and eight 12-unit subjects in Course 18 of essentially different content, including at least six advanced subjects (first decimal digit one or higher). One of these eight subjects must be 18.06 or 18.700 Linear Algebra or 18.701 Algebra I. This leaves available 84 units of unrestricted electives. The requirements are flexible in order to accommodate students who pursue programs that combine mathematics with a related field (such as physics, economics, or management) or students who are interested in both theoretical and applied mathematics.

Applied Mathematics Option
Applied mathematics focuses on the mathematical concepts and techniques applied in science, engineering, and computer science. Particular attention is given to the following principles and their mathematical formulations: propagation, equilibrium, stability, optimization, computation, statistics, and random processes. Sophomores interested in applied mathematics typically enroll in 18.310 and 18.311 Principles of Discrete and Continuum Applied Mathematics. Subject 18.310 is devoted to the discrete aspects of applied mathematics and may be taken concurrently with 18.03. Subject 18.311, given in the spring term, is devoted to continuous aspects and makes considerable use of differential equations.

The subjects in Group I of the program correspond roughly to those areas of applied mathematics that make heavy use of discrete mathematics, while Group II emphasizes those subjects that deal mainly with continuous processes. Some subjects, such as probability or numerical analysis, have both discrete and continuous aspects.

Students planning to go on to graduate work in applied mathematics should also take some basic subjects in analysis and algebra.

Theoretical Mathematics Option
Theoretical (or “pure”) mathematics is the study of the basic concepts and structure of mathematics. Its goal is to arrive at a deeper understanding and an expanded knowledge of mathematics itself.

Traditionally, pure mathematics has been classified into three general fields: analysis, which deals with continuous aspects of mathematics; algebra, which deals with discrete aspects; and geometry. The undergraduate program is designed so that students become familiar with each of these areas. Students also may wish to explore other topics such as logic, number theory, complex analysis, and subjects within applied mathematics.

The subjects 18.701 Algebra I and 18.901 Introduction to Topology are more advanced and should not be elected until a student has had experience with proofs, as in 18.100 Analysis I or 18.700 Linear Algebra.

Bachelor of Science in Mathematics with Computer Science/Course 18-C
Mathematics and computer science are closely related fields. Problems in computer science are often formalized and solved with mathematical methods. It is likely that many important problems currently facing computer scientists will be solved by researchers skilled in algebra, analysis, combinatorics, logic and/or probability theory, as well as computer science.

The purpose of this program is to allow students to study a combination of these mathematical areas and potential areas of application in computer science. Required subjects include linear algebra (18.06 or 18.700) because it is so broadly used; discrete mathematics (18.062 or 18.310) to give experience with proofs and the necessary tools for analyzing algorithms; and software construction (6.005 or 6.033) where mathematical issues may arise. The required subjects covering complexity (18.404 or 18.400J) and algorithms (18.410) provide an introduction to the most theoretical aspects of computer science.

Some flexibility is allowed in this program. In particular, students may substitute the more advanced subject 18.701 Algebra I for 18.06, and, if they already have strong theorem-proving skills, may substitute 18.314 for 18.062 or 18.310.

Minor in Mathematics
The requirements for a Minor in Mathematics are as follows:

Six 12-unit subjects in mathematics, beyond the Institute calculus requirement, of essentially different content, including at least four advanced subjects (first decimal digit one or higher).

For a general description of the minor program, see Undergraduate Education in Part 1.

Inquiries
For further information, see http://math.mit.edu/academics/undergrad/ or contact Math Academic Services, 617-253-2416.
GRADUATE STUDY

The Mathematics Department offers programs covering a broad range of topics leading to the Doctor of Philosophy or the Doctor of Science degree. Candidates are admitted to either the Pure or Applied Mathematics programs but are free to pursue interests in both groups. Of the roughly 110 doctoral students, about two-thirds are in Pure Mathematics, one-third in Applied Mathematics.

The programs in Pure and Applied Mathematics offer basic and advanced classes in analysis, algebra, geometry, Lie theory, logic, number theory, probability, statistics, topology, astrophysics, combinatorics, fluid dynamics, numerical analysis, theoretical physics, and the theory of computation. In addition, many mathematically oriented subjects are offered by other departments. Students in Applied Mathematics are especially encouraged to take subjects in engineering and scientific subjects related to their research.

All students pursue research under the supervision of the faculty and are encouraged to take advantage of the many seminars and colloquia at MIT and in the Boston area.

Doctor of Philosophy or Doctor of Science

The requirements for these degrees are described on the department’s website at http://math.mit.edu/academics/grad/timeline/. In outline, they consist of a language requirement, an oral qualifying examination, a thesis proposal, completion of a minimum of 132 units (11 graduate subjects), and a thesis containing original research in mathematics.

Financial Support

Financial support is guaranteed for four years to students making satisfactory academic progress. Financial aid after the first year is usually in the form of a teaching assistantship or research assistantship.

Inquiries

For further information, see http://math.mit.edu/academics/grad/ or contact Math Academic Services, 617-253-2416.

Bachelor of Science in Mathematics with Computer Science/Course 18-C

<table>
<thead>
<tr>
<th>General Institute Requirements (GIRs)</th>
<th>Subjects</th>
<th>Restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>2</td>
<td>can be satisfied by 18.03, 18.034, 18.06, or 18.700 in the Departmental Program</td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Total GIR Subjects Required for SB Degree</strong></td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

**Communication Requirement**

The program includes a Communication Requirement of 4 subjects:

- 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H);
- 2 subjects designated as Communication Intensive in the Major (CI-M).

**PLUS Departmental Program**

*Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).*

<table>
<thead>
<tr>
<th>Required Subjects</th>
<th>Units</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.03 or 18.034 Differential Equations, 12, REST; Calculus II (GIR)</td>
<td>96–99</td>
<td>see note 1</td>
</tr>
<tr>
<td>18.06 or 18.700 Linear Algebra, 12; 18.410J Calculus II (GIR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.410J Design and Analysis of Algorithms, 12; 6.006*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.01 Introduction to EECS I, 12, 1/2 LAB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.006 Introduction to Algorithms, 12; 6.01, 18.062</td>
<td></td>
<td></td>
</tr>
<tr>
<td>One subject from each of the following three groups:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.062J Mathematics for Computer Science, 12; Calculus I (GIR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.310A Principles of Discrete Applied Mathematics, 12; Calculus II (GIR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.310 Principles of Discrete Applied Mathematics, 15, CI-M; Calculus II (GIR)</td>
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<td></td>
</tr>
<tr>
<td>18.400J Automata, Computability, and Complexity, 12; 18.062</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.400J Theory of Computation, 12; 18.062*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.005 Elements of Software Construction, 12; 6.01, 18.062*</td>
<td></td>
<td></td>
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<tr>
<td>6.015 Computer System Engineering, 12; 6.004</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Restricted Electives</th>
<th>Units</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>60–63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Four additional 12-unit subjects from Course 18 and one additional subject of at least 12 units from Course 6. The Course 6 subject may be 6.02, 6.041, 6.17x, a Foundation or Header subject, or, with the permission of the Department of Mathematics, an advanced Course 6 subject. The overall program must consist of subjects of essentially different content, and must include at least five Course 18 subjects with a first decimal digit of 1 or higher.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To satisfy the requirements that students take two CI-M subjects, students must take two of the following subjects: 18.104, 18.304, 18.384, 18.424, 18.434, 18.504, 18.704, 18.784, 18.821, 18.904, or 18.994 or one from the above list and one of the following subjects: 6.033, 6.06, 14.33, 18.100C, or 18.310.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Departmental Program Units That Also Satisfy the GIRs**

<table>
<thead>
<tr>
<th>Units</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>24</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Unrestricted Electives**

<table>
<thead>
<tr>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>48</td>
<td></td>
<td></td>
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</tbody>
</table>

**Total Units Beyond the GIRs Required for SB Degree**

<table>
<thead>
<tr>
<th>Units</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>180–186</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No subject can be counted both as part of the 17-subject GIRs and as part of the 180 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.

**Notes**

*Alternate prerequisites and corequisites are listed in the subject description.

(1) Students may substitute the more advanced subject 18.701 Algebra I.

(2) Recommended alternative.

For an explanation of credit units, or hours, please refer to the online help in the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.
**Faculty and Staff**

**Faculty and Teaching Staff**  
Michael Sipser, PhD  
Professor of Applied Mathematics  
Department Head

Haynes R. Miller, PhD  
Professor of Mathematics  
MacVicar Faculty Fellow  
Associate Department Head

**Professors**  
- Martin Z. Bazant, PhD  
  Professor of Chemical Engineering and Applied Mathematics  
- Bonnie A. Berger, PhD  
  Professor of Applied Mathematics  
- Roman Bezrukavnikov, PhD  
  Professor of Mathematics  
- Alexei Borodin, PhD  
  Professor of Mathematics  
- John W. Bush, PhD  
  Professor of Applied Mathematics  
- Hung Cheng, PhD  
  Professor of Applied Mathematics  
- Tobias H. Colding, PhD  
  Levinson Professor of Mathematics  
- Richard Mansfield Dudley, PhD  
  Professor of Mathematics  
- Alan Edelman, PhD  
  Professor of Applied Mathematics  
- Pavel I. Etingof, PhD  
  Professor of Mathematics  
- Michel X. Goemans, PhD  
  Leighton Family Professor of Applied Mathematics  
  Chairman, Committee on Applied Mathematics  
- Victor William Guillemin, PhD  
  Professor of Mathematics  
- Alice Guionnet, PhD  
  Professor of Mathematics  
- Larry Guth, PhD  
  Professor of Mathematics  
- Sigurdur Helgason, PhD  
  Professor of Mathematics  
- David S. Jerison, PhD  
  Professor of Mathematics  
  MacVicar Faculty Fellow  
- Victor G. Kac, PhD  
  Professor of Mathematics  
  (On leave)  
- Ju-Lee Kim, PhD  
  Professor of Mathematics  
- Steven Kleiman, PhD  
  Professor of Mathematics  
- F. Thomson Leighton, PhD  
  Professor of Applied Mathematics  
- George Lusztig, PhD  
  Abdun-Nur Professor of Mathematics  
- James McKernan, PhD  
  Norbert Weiner Professor of Mathematics  
- Richard Burt Melrose, PhD  
  Simons Professor of Mathematics  
- William P. Minicozzi II, PhD  
  Professor of Mathematics  
- Tomasz S. Mrowka, PhD  
  Singer Professor of Mathematics  
  Chairman, Committee on Pure Mathematics  
- Bjorn Poonen, PhD  
  Shannon Professor of Mathematics  
- Igor Rodnianski, PhD  
  Professor of Mathematics  
- Rodolfo Ruben Rosales, PhD  
  Professor of Applied Mathematics  
- Paul Seidel, PhD  
  Professor of Mathematics  
- Scott Sheffield, PhD  
  Professor of Mathematics  
- Peter W. Shor, PhD  
  Morss Professor of Applied Mathematics  
- Gigliola Staffilani, PhD  
  Abby Rockefeller Mauzé Professor of Mathematics  
- Richard P. Stanley, PhD  
  Professor of Applied Mathematics  
- W. Gilbert Strang, PhD  
  MathWorks Professor of Mathematics  
- David Alexander Vogan, Jr., PhD  
  Professor of Mathematics

**Associate Professors**  
- Mark J. Behrens, PhD  
  Cecil and Ida B. Green Career Development Associate Professor of Mathematics  
- Benjamin B. Brubaker, PhD  
  Cecil and Ida B. Green Career Development Associate Professor of Mathematics  
  (On leave)  
- Anette E. Hosoi, PhD  
  Associate Professor of Mechanical Engineering and Applied Mathematics  
- Steven G. Johnson, PhD  
  Associate Professor of Applied Mathematics  
  (On leave, spring)  
- Jonathan A. Kelner, PhD  
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  (On leave, fall)  
- Abhinav Kumar, PhD  
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- Alexander Postnikov, PhD  
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- Katrin Wehrheim, PhD  
  Associate Professor of Mathematics

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- Jacob Fox, PhD  
  Assistant Professor of Applied Mathematics  
- Aaron Naber, PhD  
  Assistant Professor of Mathematics  
- Sug Woo Shin, PhD  
  Assistant Professor of Mathematics  
- Jared Speck, PhD  
  Assistant Professor of Mathematics
Gonçalo Tabuada, PhD  
Assistant Professor of Mathematics  
(On leave, spring)

Lie Wang, PhD  
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Adjunct Professor  
Henry Cohn, PhD  
Adjunct Professor of Applied Mathematics

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Jeremy M. Orloff, PhD

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Thomas Bitoun, PhD  
Jonathan Bloom, PhD  
Kiril Datchev, PhD  
Vadim Gorin, PhD  
Mahir Hadzic, PhD  
Stephen James Kleene, PhD  
Joseph Lauer, PhD  
Yifeng Liu, PhD  
Jason McGibbon, PhD  
Emmy Murphy, PhD  
Kyle Ormsby, PhD  
Peng Shan, PhD  
Ruipeng Shen, PhD  
Charles Smart, PhD  
Nathaniel Stapleton, PhD  
Vesna Stojanoska, PhD  
Vera Vértesi, PhD  
Chelsea Walton, PhD  
Ting Zhou, PhD

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Paul Hand, PhD  
Romain Lagrange, PhD  
Choongbum Lee, PhD  
Jonathan Novak, PhD  
Neil Olver, PhD  
Lorenzo Orecchia, PhD  
Homer Reid, PhD  
Andrew Suk, PhD  
Aaron Weters, PhD

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Eric Baer, PhD  
Vidya Venkateswaran, PhD

Statistics Instructor  
Xin Tong, PhD

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Jason Miller, PhD  
Tomer Schlank, PhD  
Vivek Shende, PhD

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Michael Artin, PhD  
Professor of Mathematics, Emeritus  
David J. Benney, PhD  
Professor of Applied Mathematics, Emeritus  
Herman Chernoff, PhD  
Professor of Applied Mathematics, Emeritus  
Daniel Z. Freedman, PhD  
Professor of Applied Mathematics and Physics, Emeritus  
Harvey Philip Greenspan, PhD  
Professor of Applied Mathematics, Emeritus  
Louis Norberg Howard, PhD  
Professor of Applied Mathematics, Emeritus  
Daniel Marinus Kan, PhD  
Professor of Mathematics, Emeritus  
Daniel J. Kleitman, PhD  
Professor of Applied Mathematics, Emeritus  
Bertram Kostant, PhD  
Professor of Mathematics, Emeritus  
Chia-Chiao Lin, PhD  
Professor of Applied Mathematics, Emeritus  
Institute Professor, Emeritus  
Willel V. R. Malkus, PhD  
Professor of Applied Mathematics, Emeritus  
Arthur Paul Mattuck, PhD  
Professor of Mathematics, Emeritus  
James Raymond Munkres, PhD  
Professor of Mathematics, Emeritus  
Hartley Rogers, PhD  
Professor of Mathematics, Emeritus  
Gerald E. Sacks, PhD  
Professor of Mathematical Logic, Emeritus  
Richard Donald Schafer, PhD  
Professor of Mathematics, Emeritus  
Isadore Manuel Singer, PhD  
Professor of Mathematics, Emeritus  
Institute Professor, Emeritus  
Harold Stark, PhD  
Professor of Mathematics, Emeritus  
Daniel W. Stroock, PhD  
Professor of Mathematics, Emeritus  
Alar Toomre, PhD  
Professor of Applied Mathematics, Emeritus
The Department of Physics offers undergraduate, graduate, and postgraduate training, with a wide range of options for specialization.

The emphasis of both the undergraduate curriculum and the graduate program is on understanding the fundamental principles that appear to govern the behavior of the physical world, including space and time and matter and energy in all its forms, from the subatomic to the cosmological and from the elementary to the complex.

The Department of Physics strives to be at the forefront of many areas where new physics can be found. Consequently, the department works on problems where extreme conditions may reveal new behavior: from clusters of galaxies or the entire universe to elementary particles or the strings that may be the substructure of these particles; from collisions of nuclei at relativistic velocities that make droplets of matter hotter than anything since the Big Bang to laser-cooled atoms so cold that their wave functions overlap, resulting in a macroscopic collective state, the Bose-Einstein condensate; and from individual atoms to unusual materials, such as high-temperature superconductors and those that are important in biology. Pushing the limits provides the opportunity to observe new general principles and test theories of the structure and behavior of matter and energy.

UNDERGRADUATE STUDY

Bachelor of Science in Physics/Course 8

An undergraduate degree in physics provides an excellent basis not only for graduate study in physics and related fields, but also for professional work in such fields as astrophysics, biophysics, engineering and applied physics, geophysics, management, law, or medicine. The undergraduate curriculum offers students the opportunity to acquire a deep conceptual understanding of fundamental physics. The core departmental requirements begin this process. The student then chooses one of two options to complete the degree: the focused option is designed for students who plan to pursue physics as a career; the flexible option accommodates those who want to tailor their physics program in a way that reflects broader interests, as well as those who are interested

### Undergraduate Curriculum

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<td>Humanities, Arts, and Social Sciences Requirement</td>
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<td>1</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(can be satisfied by 8.03 or 8.04, and 8.03 or 18.034 in the Departmental Program)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement (satisfied by 8.13 or equivalent in the Departmental Program)</td>
<td></td>
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</tr>
<tr>
<td><strong>Total GIR Subjects Required for SB Degree</strong></td>
<td></td>
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<table>
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<tr>
<th>Communication Requirement</th>
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<tr>
<td>The program includes a Communication Requirement of 4 subjects:</td>
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</tr>
<tr>
<td>2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and</td>
<td></td>
</tr>
<tr>
<td>2 subjects designated as Communication Intensive in the Major (CI-M).</td>
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</table>

### PLUS Departmental Program

<table>
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<tr>
<th>Subject names below are followed by credit units, and by prerequisites, if any (corequisites are indicated in italics).</th>
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<tr>
<td>Required Subjects</td>
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<tr>
<td>8.03 Physics II, 12, REST; Physics II (GIR), Calculus II (GIR)</td>
</tr>
<tr>
<td>8.04 Quantum Physics I, 12, REST; 8.03*, 18.03*</td>
</tr>
<tr>
<td>8.044 Statistical Physics I, 12; 8.03, 18.03</td>
</tr>
<tr>
<td>Physics: Flexible Option</td>
</tr>
<tr>
<td>One of the following subjects:</td>
</tr>
<tr>
<td>8.21 Physics of Energy, 12; Physics II (GIR), Calculus II (GIR), Chemistry (GIR)</td>
</tr>
<tr>
<td>8.223 Classical Mechanics II, 6; Physics I (GIR), Calculus II (GIR)</td>
</tr>
<tr>
<td>One of the following subjects:</td>
</tr>
<tr>
<td>8.05 Quantum Physics II, 12; 8.04</td>
</tr>
<tr>
<td>8.20 Introduction to Special Relativity, 9, REST; Physics I (GIR), Calculus I (GIR)</td>
</tr>
<tr>
<td>8.033 Relativity, 12; Physics II (GIR), Calculus II (GIR)</td>
</tr>
<tr>
<td>One of the following experimental experiences:</td>
</tr>
<tr>
<td>8.13 Experimental Physics I, 18, LAB, CI-M; 8.04</td>
</tr>
<tr>
<td>A laboratory subject of similar intensity in another department</td>
</tr>
<tr>
<td>An experimental research project or senior thesis</td>
</tr>
<tr>
<td>An experimentally oriented summer externship</td>
</tr>
<tr>
<td>Physics: Focused Option</td>
</tr>
<tr>
<td>8.033 Relativity, 12; Physics II (GIR), Calculus II (GIR)</td>
</tr>
<tr>
<td>8.05 Quantum Physics II, 12; 8.04</td>
</tr>
<tr>
<td>8.06 Quantum Physics III, 12, CI-M; 8.05</td>
</tr>
<tr>
<td>8.13 Experimental Physics I, 18, LAB, CI-M; 8.04</td>
</tr>
<tr>
<td>8.14 Experimental Physics II, 18, LAB; 8.05, 8.13</td>
</tr>
<tr>
<td>8.223 Classical Mechanics II, 6; Physics I (GIR), Calculus II (GIR)</td>
</tr>
<tr>
<td>8THU Undergraduate Physics Thesis (12 units)</td>
</tr>
</tbody>
</table>

### Restricted Electives

<table>
<thead>
<tr>
<th>At least one subject in the Department of Physics in addition to those listed above (12 units)</th>
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</thead>
<tbody>
<tr>
<td>Three subjects forming one intellectually coherent unit in some area, not necessarily physics, subject to the approval of the department (36 units)</td>
</tr>
</tbody>
</table>

### Physics: Focused Option

<table>
<thead>
<tr>
<th>One subject in the Department of Mathematics beyond 8.03 (12 units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two subjects in the Department of Physics in addition to those listed above, including at least one of the following: 8.07, 8.08, and 8.09 (24 units)</td>
</tr>
</tbody>
</table>

### Department Program Units That Also Satisfy the GIRs

| (24–36) |

### Unrestricted Electives

| 48–87 |
in other, perhaps nontraditional, career paths. Either option provides a considerable amount of time for exploration through electives. Students proceed at the pace and degree of specialization best suited to their individual capacities. Both options lead to the same degree: the Bachelor of Science in Physics.

**Physics: Focused Option**

This option—which includes three terms of quantum mechanics, 36 units of laboratory experience, and a thesis—is ideal preparation for a career in physics. In the second year, students take 8.03 Physics III, 8.033 Relativity, 8.04 Quantum Physics I, 8.044 Statistical Physics I, and 8.223 Classical Mechanics II. Important skills for experimentation in physics may be acquired by starting an Undergraduate Research Opportunities Program (UROP) project.

In the third year, students normally take laboratory subjects 8.13 and 8.14 Experimental Physics I and II, along with 8.05 and 8.06 Quantum Physics I and II. Students should also begin to take the restricted elective subjects, one in mathematics and at least two in physics. The mathematics subjects 18.04 Complex Variables with Applications, 18.075 Methods for Scientists and Engineers, and 18.06 Linear Algebra are particularly popular with physics majors. Topical elective subjects in astrophysics, biological physics, condensed matter, plasma, and nuclear and particle physics allow students to gain an appreciation of the frontiers of modern physics. Students intending to go on to graduate school in physics are encouraged to take the theoretical physics sequence 8.07 Electromagnetism II, 8.08 Statistical Physics II, and 8.09 Classical Mechanics III.

An important component of this option is the thesis, which is a physics research project carried out under the guidance of a faculty member. Many thesis projects grow naturally out of UROP projects. Students should have some idea of a thesis topic by the middle of the junior year. A thesis proposal must be submitted before registering for thesis units and no later than Add Date of the fall term of the senior year.

A relatively large amount of elective time usually becomes available during the fourth year and can be used either to deepen one’s background in physics or to explore other disciplines.

**Physics: Flexible Option**

This option is designed for students who wish to develop a strong background in the fundamentals of physics and then build on this foundation as they prepare for career paths that may not involve a graduate degree in physics. Many students find an understanding of the basic concepts of physics and an appreciation of the physicist’s approach to problem solving an excellent preparation for the growing spectrum of nontraditional, technology-related career opportunities, as well as for careers in business, law, medicine, or engineering. Additionally, the flexible option makes it more possible for students with diverse intellectual interests to pursue a second major in another department.

The option begins with the core subjects 8.01, 8.02, 8.03, 8.04, 8.044, and either 8.21 or 8.223. Students round out their foundation material with either an additional quantum mechanics subject (8.05) or a subject in relativity (8.20 or 8.033). There is an experimental requirement of 8.13 or, with the approval of the department, a laboratory subject of similar intensity in another department, an experimental research project or senior thesis, or an experimentally oriented summer externship. An exploration requirement consists of one elective subject in physics. Students can satisfy the departmental portion of the Communication Requirement by taking two of the following subjects: 8.06, 8.13, 8.225, 8.226, or 8.287). The department and the Subcommittee on the Communication Requirement may accept substitution of one of the department’s two required CI-M subjects with a CI-M subject in another department if it forms a natural part of the student’s physics program.

Students following this option must also complete a focus requirement—three subjects forming one intellectually coherent unit in some area (not necessarily physics), subject to the approval of the department and separate from those used by the student to satisfy the HASS requirement. Areas of focus chosen by students have included astronomy, biology, computational physics, theoretical physics, nanotechnology, history of science, science and technology policy, philosophy, and science teaching. Some students may choose to satisfy their experimental and exploration requirements in the same area as their focus; others may opt for greater breadth by choosing other fields to fulfill these requirements.

Although students may choose this option at any time in their undergraduate career, many decide on the flexible major during their sophomore year in order to have enough time to craft a program that best suits their individual needs. Specific subject choices for the experimental and focus requirements require the written approval of the Flexible Program coordinator, Dr. Sean P. Robinson.

**Cambridge-MIT Exchange**

The Physics Department participates in the junior-year exchange program with Cambridge University, in the United Kingdom, through the Cambridge-MIT Exchange (CME). Students with broad interests and a desire to experience a different educational environment are encouraged to explore this unique opportunity. Interested students should consult the Year or Term Away section of the chapter on Undergraduate Education in Part 1, then contact the department’s CME coordinator, Professor Peter Fisher.
Minors
The Minor in Physics provides a solid foundation for the pursuit of a broad range of professional activities in science and engineering. The requirements for a Minor in Physics are 18.03 or 18.034, plus at least five Course 8 subjects beyond the General Institute Requirements that constitute at least 57 units.

Students should submit a completed Minor Application Form to Physics Academic Programs, Room 4-315. The Physics Department’s minor coordinator is Catherine Modica. For more information on minor programs, see Undergraduate Education in Part 1.

The Minor in Astronomy, offered jointly with the Department of Earth, Atmospheric, and Planetary Sciences, covers the observational and theoretical foundations of astronomy. For a description of the minor, see Interdisciplinary Undergraduate Programs and Minors in Part 3.

Inquiries
Additional information concerning degree programs and research activities may be obtained by contacting the department at physics-grad@mit.edu or 617-253-4841.

GRADUATE STUDY
The Physics Department offers programs leading to the degrees of Master of Science in Physics, Doctor of Philosophy, and Doctor of Science.

Entrance Requirements for Graduate Study
Students intending to pursue graduate work in physics should have as a background the equivalent of the requirements for the Bachelor of Science in Physics from MIT. However, students may make up some deficiencies over the course of their graduate work.

Master of Science in Physics
The requirements for the Master of Science in Physics are the General Degree Requirements listed under Graduate Education in Part 1. The master’s thesis must represent a piece of independent research work in any of the fields described below, and must be carried out under the supervision of a department faculty member.

No fixed time is set for the completion of a master’s program; two years of work is a rough guideline. There is no language requirement for this degree.

Doctor of Philosophy and Doctor of Science
Candidates for the Doctor of Philosophy or Doctor of Science are expected to enroll in those basic graduate subjects that prepare them for the general examination, which must be passed no later than in the seventh term after initial enrollment. No specific subjects of study are prescribed, except for the requirement of two subjects in the candidate’s doctoral research area and two subjects outside the candidate’s field of specialization (breadth requirement). Half of the breadth requirement may be satisfied through a departmentally approved industrial internship. The doctoral thesis must represent a substantial piece of original research, carried out under the supervision of a department faculty member.

The Physics Department faculty members offer subjects of instruction and are engaged in research in a variety of fields in experimental and theoretical physics. This broad spectrum of activities is organized in the divisional structure of the department, presented below.

Graduate students are encouraged to contact faculty members in the division of their choice to inquire about opportunities for research, and to pass through an apprenticeship (by signing up for Pre-Thesis Research) as a first step toward an engagement in independent research for a doctoral thesis.

Research Divisions
Faculty and students in the Department of Physics are generally affiliated with one of several research divisions:

- Astrophysics
- Experimental Nuclear and Particle Physics
- Atomic Physics, Biophysics, Condensed Matter Physics, and Plasma Physics
- Theoretical Nuclear and Particle Physics

Much of the research in the department is carried out as part of the work of various interdisciplinary laboratories and centers, including the Haystack Observatory, Laboratory for Nuclear Science, Research Laboratory of Electronics, Spectroscopy Laboratory, Center for Materials Science and Engineering, MIT Kavli Institute for Astrophysics and Space Research, Francis Bitter Magnet Laboratory, Microsystems Technology Laboratories, and the Plasma Science and Fusion Center. Information on these can be found under Interdisciplinary Research and Study in Part 3. These facilities provide close relationships among the research activities of a number of MIT departments and give students opportunities for contact with research carried out in disciplines other than physics.

Inquiries
Additional information on degree programs, research activities, admissions, financial aid, teaching and research assistantships may be obtained by contacting the department at physics-grad@mit.edu or 617-253-4841.

FACULTY AND STAFF
Faculty and Teaching Staff
Edmund W. Bertschinger, PhD
Professor of Physics
Department Head

Krishna Rajagopal, PhD
Professor of Physics
MacVicar Faculty Fellow
Associate Department Head for Education
(On leave)

Professors
Raymond C. Ashoori, PhD
Professor of Physics

John Winston Belcher, PhD
Class of ’22 Professor of Physics

William Bertozzi, PhD
Professor of Physics

Wit Busza, PhD

Francis L. Friedman Professor of Physics

Claude Roger Canizares, PhD
Bruno Rossi Professor of Physics
Associate Director for MIT, Chandra X-ray Observatory Center

Vice President for Research and Associate Provost
Hong Liu, PhD  
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(On leave, fall)

Leonid Mirny, PhD  
Associate Professor of Health Sciences and Technology and Physics

Steven Nahn, PhD  
Associate Professor of Physics

Robert Simcoe, PhD  
Associate Professor of Physics

Iain W. Stewart, PhD  
Associate Professor of Physics

Joshua Winn, PhD  
Class of ’42 Career Development Associate Professor of Physics

Martin Zwierlein, PhD  
Silverman (1968) Family Career Development Associate Professor of Physics

**Assistant Professors**

Allan Adams, PhD  
Assistant Professor of Physics

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Assistant Professor of Physics

Jeremy England, PhD  
Assistant Professor of Physics

Anna Frebel, PhD  
Assistant Professor of Physics

Liang Fu, PhD  
Assistant Professor of Physics

Nuh Gedik, PhD  
Assistant Professor of Physics

Jeff Gore, PhD  
Assistant Professor of Physics

Pablo Jarillo-Herrero, PhD  
Mitsui Career Development Assistant Professor in Contemporary Technology

Markus Klute, PhD  
Assistant Professor of Physics

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Assistant Professor of Physics

Jocelyn Monroe, PhD  
Assistant Professor of Physics  
(On leave)

Jesse Thaler, PhD  
Assistant Professor of Physics

Nevin N. Weinberg, PhD  
Assistant Professor of Physics  
(On leave, fall)

Michael Williams, PhD  
Assistant Professor of Physics

Peter Dourmashkin, PhD  
George S. F. Stephans, PhD

Sean Robinson, PhD  
Technical Instructors

Charles Bosse, MAT  
Daniel Kelleher, BS

Andrew Neely, BS  
Matthew Strafuss, BS

**Research Staff**

Thomas William Donnelly, PhD  
Earl S. Marmar, PhD  
Jagadeesh S. Moodera, PhD  
Frank E. Taylor, PhD  
Richard J. Temkin, PhD

**Professors Emeriti**

Michel Baranger, PhD  
Professor of Physics, Emeritus

Ulrich Justus Becker, PhD  
Professor of Physics, Emeritus

George Bernard Benedek, PhD  
Alfred H. Caspary Professor of Physics and Biological Physics, Emeritus

Ahmet Nihat Berker, PhD  
Professor of Physics, Emeritus

Aron Myron Bernstein, PhD  
Professor of Physics, Emeritus

Robert J. Birgeneau, PhD  
Professor of Physics, Emeritus

Hale Van Dorn Bradt, PhD  
Professor of Physics, Emeritus

Bernard Flood Burke, PhD  
Professor of Physics, Emeritus

George Whipple Clark, PhD  
Professor of Physics, Emeritus

Eric Richard Cosman, PhD  
Professor of Physics, Emeritus

Peter Theodore Demos, PhD  
Professor of Physics, Emeritus

Mildred Spiewak Dresselhaus, PhD  
Professor of Electrical Engineering and Physics, Emerita

Institute Professor, Emerita

Thomas H. Dupree, PhD  
Professor of Physics, Emeritus

Anthony Philip French, PhD  
Professor of Physics, Emeritus

Jerome Isaac Friedman, PhD  
Professor of Physics, Emeritus

Institute Professor, Emeritus

Jeffrey Goldstone, PhD  
Professor of Physics, Emeritus

Thomas John Greytak, PhD  
Lester Wolfe Professor of Physics, Emeritus

Lee Grodzins, PhD  
Professor of Physics, Emeritus

Kerson Huang, PhD  
Professor of Physics, Emeritus

Karl Uno Ingard, PhD  
Professor of Aeronautics and Astronautics and Physics, Emeritus

Roman Wladimir Jackiw, PhD  
Jerrold Zacharias Professor of Physics, Emeritus

Ali Javan, PhD  
Professor of Physics, Emeritus

Arthur Kent Kerman, PhD  
Professor of Physics, Emeritus

John Gordon King, PhD  
Francis Friedman Professor of Physics, Emeritus

Vera Kistiakowsky, PhD  
Professor of Physics, Emerita

Daniel Kleppner, PhD  
Professor of Physics, Emeritus

Benjamin Lax, PhD  
Professor of Physics, Emeritus
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<td>Biomedical Engineering</td>
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<td>Energy Studies</td>
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<td>Psychology</td>
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<td>Public Policy</td>
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<td>Women’s and Gender Studies</td>
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UNDERGRADUATE PROGRAMS

American Studies
American Studies at MIT offers students the opportunity to organize subjects from various fields (e.g., history, anthropology, literature, political science, music, art and architecture, and urban studies) into personally constructed interdisciplinary programs as a way of gaining an integrated understanding of American society and culture.

American Studies is a field of concentration; it is also available as the humanities component of a joint major program (the 21E and 21S degrees), or as a full major by special arrangement. American Studies majors work out a coherent program of study with an advisor, usually including two subjects each in literature and history, although variations are possible. Major programs can center on a particular interest or aim more broadly at a comprehensive knowledge of various aspects of American life and culture.

The coordinator of American Studies is Professor Meg Jacobs, Room E51-263, 617-253-7895, mjacobs@mit.edu.

Ancient and Medieval Studies
Through a wide variety of subjects drawn from a number of disciplines, this program provides a curricular framework for exploring topics in ancient and medieval studies which range from the history of ideas and institutions to that of material artifacts, literature, and certain original languages. The program spans the 6,500 years between 5000 BC and 1500 AD.

This program’s goal is to develop knowledge and understanding of the more distant past both for itself, in its uniqueness, and as an object of specifically modern questions and methods of inquiry. The program has an interest in the structure of institutions and social systems, and in relationships between the social order and learned traditions, values, ideologies, and ideas. Ancient and medieval studies derive a special claim to our interest from the fact that the record is so full and multiform and that much of it is of exceptionally high quality at once in substance and form.

Ancient and Medieval Studies is available as a concentration, a minor, and as a major department within Course 21. Individual programs are to be determined in consultation with Professor Anne E. C. McCants, Room E51-255, 617-258-6669, amccants@mit.edu (fall); Professor William Broadhead, Room E51-257, 617-258-6668, williamb@mit.edu (spring).

Program in Psychology
Psychology, the study of human mental life and behavior, is represented at MIT as a program in the Department of Brain and Cognitive Sciences, and as a concentration within the undergraduate HASS Requirement. Faculty and subjects in psychology are found in many MIT departments, including Brain and Cognitive Sciences, Management, History, and STS. Students who wish to concentrate in psychology take a set of subjects from these departments, chosen in consultation with the concentration officer for the Program in Psychology.

Students who wish a more substantial education in the field may pursue a Minor in Psychology, described in further detail in the following section on minors.

In addition to taking psychology subjects, undergraduates may take advantage of a wide range of research opportunities (generally via the Undergraduate Research Opportunities Program). Students should contact UROP coordinators from specific departments about projects currently available.

For more information about the Program in Psychology, contact Professor Alan Hein, Room 46-2047, 617-253-5759, hein@mit.edu, or the Brain and Cognitive Sciences Undergraduate Office, Room 46-2005, 617-253-0482.

Women’s and Gender Studies Program
Women’s and Gender Studies (WGS) is an interdisciplinary inquiry into the significance of gender in human society and thought, both in the United States and around the world. Drawing on more than 50 years of scholarly work centered on gender analysis as well as research in many traditional fields, the program explores questions such as how women and men learn their gender roles; how different societies define women and men; and how ideas of sex and gender shape and are shaped by language, individual behavior, and social institutions such as law, religion, and education. Students explore the varied roles gender has played in different cultures, times, intellectual disciplines, and forms of creative expression. Debates over sexuality, reproduction, feminism, masculinquity, the roles of women in history, politics, and science, and the intersections of gender with other social categories such as race, class, ethnicity are all topics addressed within this interdisciplinary field.

Most subjects in the field of Women’s and Gender Studies are cross-listed with other departments and are available to students in a wide range of fields of study. Through classes, UROPs, and events, both undergraduate and graduate students gain new perspectives on other disciplines such as computer science, law, philosophy, theater, management, literature, urban studies, psychology, and history. WGS subjects are open to all students.

The curriculum includes a core subject, Introduction to Women’s and Gender Studies, and a selection of subjects from many departments at the Institute, listed in the WGS section of the MIT Subject Listing & Schedule. A full major (known as a major departure) is available by special arrangement. WGS also offers a minor program (see below) and a concentration.

For more information, contact the coordinator, Heidy M. González, Room 14E-316, 617-253-8844, or visit http://web.mit.edu/wgs/.
Bachelor of Science in Computer Science and Molecular Biology/Course 6-7
The Department of Biology and the Department of Electrical Engineering and Computer Science offer a joint undergraduate curriculum that focuses on the emerging field of computational and molecular biology. The curriculum provides strong foundations in both biology and computer science and features innovative, integrative, capstone and elective subjects. The goal is to produce an entirely new cadre of graduates who are uniquely qualified to address the challenges and opportunities at the interface of computational and molecular biology.

Students in the program are first-class citizens in two departments (Biology and EECS) and in two schools (Science and Engineering), with one academic advisor from each department.

Completion of the curriculum leads to the Bachelor of Science in Computer Science and Molecular Biology and prepares students for careers that leverage computational biology (e.g., pharmaceuticals, bioinformatics, medicine, etc.) as well as further graduate study in biology, in pharmaceuticals, bioinformatics, medicine, etc.) as well as further graduate study in biology, in computer science, and in emerging programs at the interface.

Information about the program is available in both the EECS and Biology Undergraduate Offices. Please visit http://web.mit.edu/biology/, Room 68-120, 617-253-4718, and/or http://web.mit.edu/eeecs/, Room 38-476, 617-253-4654.

### Bachelor of Science in Computer Science and Molecular Biology/Course 6-7

<table>
<thead>
<tr>
<th>General Institute Requirements (GIRs)</th>
<th>Subjects</th>
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<tbody>
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<tr>
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<td>8</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement [can be satisfied by 6.042, 18.03, or 18.06 in the Departmental Program]</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement [can be satisfied by 7.02 in the Departmental Program]</td>
<td>1</td>
</tr>
<tr>
<td>Total GIR Subjects Required for SB Degree</td>
<td>17</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Communication Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>The program includes a Communication Requirement of 4 subjects: 2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and 2 subjects designated as Communication Intensive in the Major (CI-M).</td>
</tr>
</tbody>
</table>

### PLUS Departmental Program

<table>
<thead>
<tr>
<th>Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).</th>
</tr>
</thead>
</table>

### Required Subjects

<table>
<thead>
<tr>
<th>Mathematics and Introductory</th>
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</thead>
<tbody>
<tr>
<td>18.03 Differential Equations, 12, REST; Calculus II (GIR)</td>
</tr>
<tr>
<td>or</td>
</tr>
<tr>
<td>18.06 Linear Algebra, 12, REST; Calculus II (GIR)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chemistry</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.01 Introduction to EECS I, 12, 1/2 LAB; Physics II (GIR)</td>
</tr>
<tr>
<td>6.042J Mathematics for Computer Science, 12, REST; Calculus I (GIR)</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Plus GIR Subjects Required for SB Degree</th>
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<tbody>
<tr>
<td>147–150</td>
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### Total Units

<table>
<thead>
<tr>
<th>Foundational Subjects</th>
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</thead>
<tbody>
<tr>
<td>Three Computer Science subjects:</td>
</tr>
<tr>
<td>6.005 Elements of Software Construction, 12; 6.01, 6.042J</td>
</tr>
<tr>
<td>6.006 Introduction to Algorithms, 12; 6.01, 6.042J*</td>
</tr>
<tr>
<td>6.046J Design and Analysis of Algorithms, 12; 6.006*</td>
</tr>
</tbody>
</table>

| Three Biological Science subjects: |
| 7.03 Genetics, 12, REST; Biology (GIR) |
| 7.06 Cell Biology, 12; 7.03, 7.05 |
| 7.05 General Biochemistry, 12, REST; 5.12* |
| or |
| 5.07 Biological Chemistry I, 12, REST; 5.12 |

<table>
<thead>
<tr>
<th>Restricted Electives</th>
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</thead>
<tbody>
<tr>
<td>One subject in Computational Biology:</td>
</tr>
<tr>
<td>6.047 Computational Biology: Genomes, Networks, Evolution, 12; 6.006, 6.041, Biology (GIR)*</td>
</tr>
<tr>
<td>6.048 Computational Evolutionary Biology, 12; 6.041*</td>
</tr>
<tr>
<td>6.091 Foundations of Algorithms and Computational Techniques in Systems Biology, 12; 6.046*</td>
</tr>
<tr>
<td>6.082 Computational Functional Genomics, 12; Biology (GIR), 6.041*</td>
</tr>
<tr>
<td>7.36 Foundations of Computational and Systems Biology, 12; Biology (GIR)*</td>
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</tbody>
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<table>
<thead>
<tr>
<th>One subject in Biology:</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.201 Human Physiology, 12; 7.05</td>
</tr>
<tr>
<td>7.22 Immunology, 12; 7.03*</td>
</tr>
<tr>
<td>7.27 Principles of Human Disease, 12; 7.03, 7.05, 7.06</td>
</tr>
<tr>
<td>7.28 Molecular Biology, 12; 7.03, 7.05</td>
</tr>
<tr>
<td>7.33 Evolutionary Biology: Concepts, Models, and Computation, 12; 7.03, 6.00*</td>
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<tr>
<th>Advanced Undergraduate Project</th>
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<tbody>
<tr>
<td>6.046J and 6.0AT Undergraduate Advanced Project, 12; CI-M</td>
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</table>

<table>
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<tr>
<th>Departmental Program Units That Also Satisfy the GIRs</th>
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<tr>
<td>(36)</td>
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<table>
<thead>
<tr>
<th>Unrestricted Electives</th>
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<tr>
<td>48</td>
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</tbody>
</table>
MINORS

Minor in Applied International Studies
MIT students expect to be full participants in the global economy and research environment. The interdisciplinary HASS Minor in Applied International Studies prepares them for this reality by integrating international learning and experiences into a six-subject program of study that encompasses four distinct requirements. To ensure coherence in their chosen coursework, students must declare a region and language of focus.

The first area of focus is that of language and culture. Lasting economic and social relationships in an international context are only possible for those who speak the language of a foreign country and are familiar with its cultural dimensions. Therefore, students must be proficient in a foreign language (level IV or better).

Students may choose from a broad range of subject offerings to fulfill the social science component of the program. This component provides students with an understanding of economic, political, cultural, and historical concepts that are essential to understanding the interconnectedness of the modern world. Within this general area, students must choose at least two subjects focused on their declared region of interest.

Recognizing that theoretical learning should be combined with hands-on experience, the Minor in Applied International Studies includes a required stay-abroad component that exposes students to the challenges and opportunities of working and living in another culture. Students select their options in close consultation with the minor advisor. The experience abroad will typically take place in the form of an internship, research stay, service learning opportunity (for which students do not usually receive credit), or study abroad, and must be at least 10 weeks in length.

Independent research rounds out the requirements of the minor. In the context of the required research seminar, students select their own topics for research in the social sciences; develop their research during the term, in consultation with the instructor; and complete the research with a substantial paper.

The requirements are summarized in more detail below.

Area I

Equivalent of four terms of college language training related to student’s geographical specialization. Language subjects beyond level II may count toward Area II requirement.

Area II

Five subjects from any program in SHASS, including at least one social science subject, and at least two subjects focused on the student’s declared region of interest.

Area III

International experience of at least 10 weeks.

Area IV

Research seminar in international studies and social science offered annually in the Political Science Department, or another subject with a substantial independent research component. Examples of subjects that may be used to complete this requirement (with prior approval by the minor advisor) are 17.145, 17.405, 17.483, and 17.921J.

Ben Schneider in the Department of Political Science is the minor advisor, E53-407, 617-253-2070, brs@mit.edu. Additional information can be obtained from Tobie Weiner, undergraduate administrator in Political Science, E53-483, 617-253-3649, iguanatw@mit.edu.

Minor in Astronomy

The Minor in Astronomy, offered jointly by the Department of Earth, Atmospheric, and Planetary Sciences and the Department of Physics, covers the observational and theoretical foundations of astronomy. The minor requires seven subjects as follows:

Astronomy, Mathematics, and Physics

Required subjects:
8.03 Physics III
8.28J Introduction to Astronomy
18.03 Differential Equations

Astrophysics

Choose one:
8.284 Modern Astrophysics
8.286 The Early Universe

Planetary Astronomy

Choose one:
12.008 Classical Mechanics: A Computational Approach
12.400 The Solar System
12.420 Physics and Chemistry of the Solar System
12.425 Extrasolar Planets: Physics and Detection Techniques

Instrumentation and Observations

Choose one:
8.287J Observational Techniques of Optical Astronomy
12.43 J Space Systems Engineering
12.431J Space Systems Development I
12.432J Space Systems Development II

Independent Project in Astronomy

Choose one:
8.UR or 12.UR Undergraduate Research
8.ThU or 12.ThU Undergraduate Thesis
12.411 Astronomy Field Camp

Four of the subjects used to satisfy the requirements for the astronomy minor may not be used to satisfy any other minor or major.

Further information on the minor may be obtained from Professor Paul Schechter, 37-664G, 617-253-0690, schech@mit.edu.
**Minor in Biomedical Engineering**
The Minor in Biomedical Engineering is open to all students who do not major in Course 20. This program includes broad science and engineering fundamentals that support applications in biomedical engineering, and is distinct from the goals of the Course 20 major. A total of eight subjects is required; note that 5.12 is a prerequisite to both options for the Science Core requirement.

The Minor in Biomedical Engineering consists of the following:

**Engineering Core**
- 18.03 Differential Equations
- 7.02J Introduction to Experimental Biology and Communication
- 7.03 Genetics
- 7.06 Cell Biology
- 5.07J Biological Chemistry I
- 6.007 Electromagnetic Energy: From Motors to Lasers
- 6.041J Thermodynamics of Biomolecular Systems
- 7.06J Cell Biology
- 14.01 Principles of Microeconomics

**Science Core**
- 5.07J Biological Chemistry I
- 6.007 Electromagnetic Energy: From Motors to Lasers
- 12.021 Earth Science, Energy, and the Environment
- 14.01 Principles of Microeconomics

**Biology and Engineering Baseline**
Choose two:
- 18.440 Statistics for Brain and Cognitive Science
- 18.443 Probability and Random Variables
- 18.441 Probability and Random Variables
- 5.07 Biological Chemistry I
- 6.007 Electromagnetic Energy: From Motors to Lasers
- 13.01 Principles of Microeconomics

**Biomedical Engineering and Applications**
One of the following:
- 20.310 Molecular, Cellular, and Tissue Biomechanics
- 20.320 Analysis of Biomolecular and Cellular Systems
- 20.330 Fields, Forces, and Flows in Biological Systems
- 20.371 Quantitative Systems Physiology
- 20.390 Foundations of Computational and Systems Biology

**Core Curriculum**

**Science Foundations**
Choose one of the following options:

**Option 1:**
- 8.21 Physics of Energy

**Option 2:**
- Choose one group of two subjects from the list below:
  - **Group A**
    - 6.007 Electromagnetic Energy: From Motors to Lasers
    - 2.005 Thermal-Fluids Engineering I
    - 5.60 Thermodynamics and Kinetics
  - **Group B**
    - 2.005 Thermal-Fluids Engineering I
    - 5.60 Thermodynamics and Kinetics
  - **Group C**
    - 6.007 Electromagnetic Energy: From Motors to Lasers
    - 12.021 Earth Science, Energy, and the Environment

**Minor in Energy Studies**
Energy is a fundamentally multidisciplinary topic. Transforming the world’s energy systems requires combining expertise from numerous fields in engineering and technology, natural and social science, and policy. A diversity of disciplinary perspectives is necessary to equip students to work in this complex, evolving field.

The Energy Studies Minor for undergraduates is an Institute-wide program that complements the deep expertise obtained in any major with a broad understanding of the interlinked realms of science, technology, and social sciences as they relate to energy and associated environmental challenges. The minor curriculum integrates these three domains in a thoroughly multidisciplinary program. A faculty oversight committee including representatives from all five Schools oversees the Energy Studies Minor program.

The Energy Studies curriculum has two components. The first is a core that provides an integrated perspective on energy and associated environmental challenges in three domains, each with a primary focus: Science Foundations (fundamental laws and principles that govern energy sources, conversion, and uses), Social Science Foundations (social scientific perspectives and tools that explain human behavior in the energy context), and Technology/Engineering in Context (the application of laws and principles to a specific energy context). The second component is a customized program of electives that is selected by each student in close consultation with his or her Energy Studies Minor faculty advisor.

**For further information, please visit the Biological Engineering website at [http://web.mit.edu/be/](http://web.mit.edu/be/) or contact the BE Academic Office, Room 56-651, 617-253-1712.**
**Technology/Engineering in Context**

Choose one of the following:

- 2.60j Fundamentals of Advanced Energy Conversion
- 4.42j Fundamentals of Energy in Buildings
- 22.081j Introduction to Sustainable Energy

**Electives**

Choose 24 units from the following (all subjects 12 units unless otherwise noted): *

- 1.07j Global Change Science
- 1.80j Environmental Law, Policy, and Economics: Pollution Prevention and Control
- 2.006 Thermal-Fluids Engineering II
- 2.570 Nano-to-Macro Transport Processes
- 2.612 Marine Power and Propulsion
- 2.627 Fundamentals of Photovoltaics
- 2.813 Energy, Materials, and Manufacturing
- 3.003 Principles of Engineering Practice (9 units)
- 3.004 Principles of Engineering Practice
- 4.401 Architectural Building Systems
- 4.472 Design Workshop for a Sustainable Future (9 units)
- 6.061 Introduction to Electric Power Systems
- 6.131 Power Electronics Laboratory
- 6.701 Introduction to Nanoelectronics
- 10.04j A Philosophical History of Energy
- 10.27 Energy Engineering Projects Laboratory (15 units)
- 10.426 Electrochemical Energy Systems
- 11.162 Politics of Energy and the Environment
- 11.165 Infrastructure in Crisis: Energy and Security Challenges
- 11.168 Enabling an Energy-Efficient Society
- 12.213 Alternate Energy Sources (6 units)
- 14.42 Environmental Policy and Economics
- 14.44 Energy Economics and Policy
- 15.026j Global Climate Change: Economics, Science, and Policy (9 units)
- 21H.318 The Energy Crisis: Past and Present
- 22.033 Nuclear Systems Design Project
- 22.06 Engineering of Nuclear Systems
- EC.711 D-Lab: Energy
- STS.032 Energy, Environment, and Society

Students who take more than the required subjects from any of the core curriculum subject lists may count the additional coursework toward the elective requirement. Contact Christie Ko, academic coordinator, MITEI Education Office, Room E19-370D, 617-253-3478, cko@mit.edu, or visit [http://web.mit.edu/energystudies/](http://web.mit.edu/energystudies/) for more information.

**Minor in Psychology**

The Program in Psychology encompasses subjects from the Department of Brain and Cognitive Sciences; Sloan School of Management; Program in Science, Technology, and Society; and other areas.

The Minor in Psychology consists of six subjects arranged in three levels of study that provide students breadth in the field as a whole and some depth in one or two areas of specialization. The three levels are as follows.

**Tier I**

- Course 9.00 Introduction to Psychology

**Tier II**

- **One subject:**
  - Course 9.00 Introduction to Psychology
- **Two subjects, one from any two of the following areas:**
  - Experimental Psychology
  - Personality and Social Psychology
  - Applied Psychology

**Tier III**

- **Three subjects from one or two of the following areas:**
  - Experimental Psychology
  - Personality and Social Psychology
  - Applied Psychology

Only 9.00 may be double-counted to satisfy the requirements for the Bachelor of Science in Brain and Cognitive Sciences and the Minor in Psychology.

For information about the Psychology Program and a listing of available subjects in these areas, consult the BCS Undergraduate Office, Room 46-2005, 617-253-0482.

**Minor in Public Policy**

Public policy is an academic field that focuses on how government action can enhance the quality of life of citizens. The interdisciplinary HASS Minor in Public Policy is intended to provide a framework for students in engineering and sciences who are interested in the role of public policy in the field of their technical expertise. Because the Course 11 major has a strong public policy element and several subjects are redundant, Course 11 majors are not eligible for the Minor in Public Policy.

The six-subject minor is organized along three dimensions. The first dimension is a foundation built on the study of the institutions in which public policy decisions are made and implemented. All students take two subjects that introduce them to justifications for government action—justifications that form the fundamental basis for making public policy. The second dimension is the study of the methods for assessing the impacts of policy change on policy outcomes. The purpose is to provide students with a basic understanding of the range of approaches professionals use to evaluate public policies. The third dimension is an in-depth study of policymaking in one substantive field. All minors specialize in an area of public policy, such as science and technology policy, and take three subjects within that specialty. Students may also do an internship to fulfill one part of the three-subject requirement.

**Tier I**

- Introduction to Markets, Politics, and Public Policy (two required subjects)
- 11.002/17.30J Making Public Policy

**Tier II**

- Policy Analysis (one required subject)
- 11.003/17.30J Methods of Policy Analysis

**Tier III**

- Policy Concentration
  - Three subjects chosen in one of the following tracks: social and educational policy, environmental policy, infrastructure policy, science and technology policy, labor and industrial policy, international development policy, security and defense policy, and urban and regional policy.
  - Students may propose their own track for approval by their minor advisor; students may substitute a semester-long internship in their chosen field for one subject, with the approval of their minor advisor.
Students can obtain additional information from the Public Policy website, [http://web.mit.edu/polisci/academic-programs/undergraduate/minorpublicpolicy.shtml](http://web.mit.edu/polisci/academic-programs/undergraduate/minorpublicpolicy.shtml); Sandra Wellford, undergraduate administrator in Urban Studies and Planning, Room 7-346A, 617-253-9403; or Tobie Weiner, undergraduate administrator in Political Science, Room E53-483, 617-253-3649, iguanatw@mit.edu.

### Minor in Women's and Gender Studies

The Minor Program in Women's and Gender Studies is designed for students who, in addition to the focus of their major program of study, seek a fuller understanding of the ways in which gender and other constructs have shaped our understanding of ourselves and of the communities and world in which we live. The minor program consists of six Women’s and Gender Studies subjects, one of which may be taken at Harvard or Wellesley with the permission of the director, arranged into three levels of study as follows:

- **Tier I**
  - **Required introductory subject:**
  
  WGS.101 Introduction to Women’s and Gender Studies

- **Tier II**
  - **Four subjects, at least one of which is drawn from each category:**
  
  - Humanities and the arts
  - Social and natural sciences

- **Tier III**
  - **One advanced seminar:**
    - Feminist Political Thought
    - An upper-level Women’s and Gender Studies subject
    - as determined by the director

For more information, contact the coordinator, Heidy M. González, Women’s and Gender Studies, Room 14E-316, 617-253-8844, wgs@mit.edu, or visit [http://web.mit.edu/wgs/](http://web.mit.edu/wgs/).

### HASS Minors in Regional Studies

Several Minors in Regional Studies are offered at MIT: African and African Diaspora Studies, Asian and Asian Diaspora Studies, Latin American and Latino Studies, Middle Eastern Studies, and Russian and Eurasian Studies. These interdisciplinary programs provide MIT undergraduates with valuable opportunities to acquire knowledge of a particular country, region, or culture. This better prepares them for academic, business, and government careers in a world where regions, countries, and cultures are increasingly interdependent.

Because the nature of these minors is cross-disciplinary, typically combining foreign language study with humanities, arts, and social sciences, they are arranged into the following four areas of study:

- **Area I:** Language (Intermediate level)
- **Area II:** Humanities and the Arts
- **Area III:** Social Sciences
- **Area IV:** Historical Studies

Students are required to take six subjects (at least three of which must be MIT subjects) typically in the following configuration: two language subjects, beginning at the second year or third term (Area I), and four other subjects, chosen from at least two of the other three areas. If a student already has achieved the equivalent of intermediate-level language proficiency, he or she can take either two more advanced-level language subjects or two more subjects from Areas II, III, or IV in place of the intermediate language subjects. Languages not presently taught at MIT may be taken at Harvard or Wellesley, or elsewhere during the summer or IAP with the permission of the minor advisor.

Details on each of the minors are given below. Lists of subjects that are appropriate for a HASS minor in each of the regional studies, as well as additional information about minors, advisors, etc., can be obtained from the relevant minor advisor or from the HASS academic administrator, Room 4-240, lizf@mit.edu.

### Minor in African and African Diaspora Studies

The Minor in African and African Diaspora Studies is designed for students interested in the cultures and experiences of the peoples of African descent on the continent and elsewhere. The minor includes study of economic and political systems as they reflect the African continent and areas of the African diaspora, and the histories, languages, and literatures of Africans and peoples of African descent elsewhere. All of Africa falls within the geographical scope of the minor. A student may concentrate on a particular region or on any of the broad groupings of African cultures, such as Arabic-speaking, Anglophone, Francophone, or Lusophone Africa. Equally, a student choosing to focus on the African diaspora may concentrate on any group of African-descended populations in the Americas. Students focusing on either principal area (Africa or the African diaspora) must also take at least one subject which deals with the other area or with interactions between them. The goal of the minor program is to emphasize the importance of Africa and people of African descent in world cultural, economic, and social developments, and to provide a balance between language, humanistic, and contemporary study.

Students are expected to have two intermediate (Levels III and IV) subjects in either the official language of the region of study or in an indigenous African language. In cases where the student is specializing in Anglophone Africa or an English-speaking region of the diaspora, and does not undertake study of an indigenous language, or is a native speaker of the official language(s) of a country or region of emphasis, this component would be replaced by literature or other humanities subjects.

Additional information can be obtained from the minor advisor, Professor Helen Elaine Lee, Room 14N-425, 617-253-3060, helee@mit.edu, or from the HASS academic administrator, Room 4-240, lizf@mit.edu.

### Minor in Asian and Asian Diaspora Studies

The Minor in Asian and Asian Diaspora Studies is designed for students interested in the language, history, politics, and culture of Asia and/or the Asian diasporas. In consultation with the minor advisor, students may focus their coursework on a subregion of Asia, on one of the Asian diasporas, or design their program to offer a comparative study across different regions and/or cultural groups. The goal of the minor program is to provide balanced coverage of language, humanistic and social science offerings on the region, and to expose students to comparative perspectives.

The language requirement can be satisfied by taking two intermediate (Levels III and IV, or Very Fast Track equivalent) subjects in an Asian language. Students with proficiency at this level
are encouraged to take two more advanced language subjects. Alternatively, they may take two more subjects from Areas II–IV. Chinese and Japanese are currently taught at MIT. Other languages may be taken at Harvard or Wellesley, or at other institutions during IAP or the summer, with permission from the minor advisor. In cases where the student is specializing in an Asian country where English is one of the official languages, in an English-speaking region of the diaspora, or is a native speaker of an Asian language, the Area I component may be replaced by subjects from Areas II–IV in consultation with the minor advisor.

Additional information can be obtained from the minor advisor, Professor Emma Teng, Room 14N-421, 617-253-4536, eteng@mit.edu, or from the HASS academic administrator, Room 4-240, lizf@mit.edu.

Minor in Latin American and Latino Studies
The Minor in Latin American and Latino Studies is designed for students interested in the languages, history, politics, and cultures of Latin America. Currently, more relevant offerings at MIT concentrate on those areas formerly colonized by Spain, although students are not required to focus their study exclusively on these areas. They are encouraged to develop a program that is both international and comparative in perspective and that takes into account the heterogeneous cultural experiences of people living in the vast territory loosely termed Latin America, as well as of those living in the United States who identify themselves as Latino.

Two language subjects beginning at Levels III and IV, either in Spanish or Portuguese, satisfy the Area I language requirement. MIT offers Levels III and IV of Spanish and Portuguese every semester. All students opting for the minor are required to take 21F.084J/17.55J/21A.430J Introduction to Latin American Studies.

Latin American and Latino Studies is available as a concentration, a minor, and as a major departure within Course 21.

Additional information can be obtained from the minor advisor, Professor Elizabeth Garrels, Room 14N-323, 617-253-9688, egarrels@mit.edu, or from the HASS academic administrator, Room 4-240, lizf@mit.edu.

Minor in Middle Eastern Studies
Middle Eastern Studies at MIT offers students the opportunity to explore the connections among culture, society, politics, economics, technology, and environment in the Middle East, including North Africa. MIT offers a number of subjects open to undergraduates that provide a variety of perspectives on the ancient, Islamic, and modern Middle East. The goal of the HASS Minor Program in Middle Eastern Studies is to lead the student from the basic language into survey subjects and then into more focused studies of individual countries or specific historical periods, and to encourage analysis of the main methodological and conceptual issues in Middle Eastern Studies.

Two intermediate (Levels III and IV) subjects in one of the following Middle Eastern languages are required: Arabic, Hebrew, Persian, or Turkish. Because MIT does not offer instruction in these languages, students may satisfy the Area I language requirement at Harvard University or Wellesley College. They may satisfy the language requirement at other institutions provided they receive permission in advance from the HASS minor advisor in Middle Eastern Studies.

Additional information can be obtained from the minor advisor, Professor Philip S. Khoury, Room 10-280, 617-253-0887, khoury@mit.edu, or from the HASS academic administrator, Room 4-240, lizf@mit.edu.

Minor in Russian and Eurasian Studies
The Minor in Russian and Eurasian Studies is intended for students seeking an interdisciplinary program of study centered on Russia and Eurasia. The program is regional in spirit, meaning that students can take subjects about a wide range of countries of East/Central Europe, the Slavic states, and Central Asia.

Two intermediate (Levels III and IV) subjects in the Russian language are required to satisfy Area I. These subjects are not offered at MIT, but may be taken at Harvard University or Wellesley College through cross-registration. For more information, see Undergraduate Education in Part 1.

Additional information can be obtained from the minor advisor, Professor Elizabeth Wood, Room E51-282, 617-253-3255, elizwood@mit.edu, or from the HASS academic administrator, Room 4-240, lizf@mit.edu.
**INTERDISCIPLINARY GRADUATE PROGRAMS**

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<td>Operations Research</td>
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<td>Polymer Science and Technology</td>
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<td>Harvard-MIT Division of Health Sciences and Technology</td>
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<td>Transportation</td>
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At MIT, students and faculty from different fields work together in a variety of collaborative programs that extend beyond departmental or school boundaries. The programs listed in this section offer interdisciplinary graduate degrees.

Computation for Design and Optimization Program

Computation for Design and Optimization (CDO) is an interdisciplinary master’s degree program that provides students with a strong foundation in computational methods for the design and operation of complex engineered and scientific systems. The CDO program is administered by the Center for Computational Engineering.

The CDO program educates students in the formulation, analysis, implementation, and application of computational approaches to designing and operating engineered systems. The curriculum’s common core serves all engineering disciplines, and an elective component focuses on particular applications. The program emphasizes:

- Breadth through introductory courses in numerical analysis and simulation, and optimization
- Depth in optimization methods and numerical methods for partial differential equations
- Multidisciplinary aspects of computation
- Hands-on experience through projects, assignments, and a master’s thesis

Participating faculty come from the Schools of Engineering, Science, and Management, including the Departments of Aeronautics and Astronautics, Biological Engineering, Chemical Engineering, Civil and Environmental Engineering, Electrical Engineering and Computer Science, Engineering Systems, Mathematics, Mechanical Engineering, and Nuclear Science and Engineering.

The research interests of CDO faculty cover a great variety of computationally intensive areas in engineering, science, and mathematics. Recent research has included such far-ranging topics as micromachined devices, guidance/ control systems, imaging systems, distribution networks, telecommunications systems, and transportation systems. CDO faculty research encompasses applications in areas such as
aircraft design, materials design, manufacturing operations scheduling, and applied optimization in operations and industrial engineering.

Inquiries
For more information about the CDO program, contact Barbara Lechner, Room 35-329, 617-253-3725, cdo_info@mit.edu; or visit http://computationalengineering.mit.edu/education/.

Leaders for Global Operations Program
The Leaders for Global Operations (LGO) program is an educational and research partnership among global operations companies and MIT’s School of Engineering and the MIT Sloan School of Management. Its objective is to discover, codify, teach, and otherwise disseminate guiding principles for world-class manufacturing and operations.

The 24-month LGO program combines graduate education in engineering and management for those with two or more years of full-time work experience who aspire to leadership positions in manufacturing or operations companies. A required 6.5-month internship provides opportunity to complete a research project on site at one of LGO’s partner companies. The internship leads to a dual-degree thesis, culminating in two master’s degrees—an MBA (or SM in management) and an SM in engineering. The program is offered jointly through the MIT Sloan School of Management and the School of Engineering master’s programs in:

- Aeronautics and Astronautics
- Biological Engineering
- Chemical Engineering
- Civil and Environmental Engineering
- Electrical Engineering and Computer Science Engineering Systems
- Mechanical Engineering

For additional information, visit http://lgo.mit.edu/, or see the program description under Engineering Systems Division or the MIT Sloan School of Management.

Operations Research Programs
Operations research (OR) is the discipline of applying advanced analytical methods to help make better decisions. It uses mathematical modeling, analysis, and optimization in a holistic approach to improving our knowledge of systems and designing useful, efficient systems. Its applications range from engineering to management, and from industry to the public sector.

Operations research has helped advance the mathematics of optimization, applied probability, and statistics. OR researchers, collaborating with colleagues in related fields, have created innovative methods for pricing goods and services, and for marketing them. They have contributed to improving transportation, developing new financial instruments and auctions, and analyzing biological and medical information, as well as many more areas. In today’s complex and interconnected world, the rigorous techniques and methodologies of operations research have become especially important aids to informed decision making.

The Operations Research Center (ORC) coordinates an SM program and a PhD program, providing a strong background in OR theory as well as the practical techniques used in building models for a wide variety of applications.

Founded as an interdepartmental program, the Operations Research Center has maintained its interdisciplinary roots. Its faculty comes from nine different departments at MIT, including the Sloan School of Management, five of the engineering departments, the Department of Mathematics, the Department of Economics, and the Department of Urban Studies and Planning.

Information about the Operations Research Center and its degree programs is available on the ORC website at http://web.mit.edu/orc/www/.

For further information, contact Laura Rose, Room E40-143, 617-253-9303, lrose@mit.edu.

Program in Polymer Science and Technology
The Schools of Engineering and Science have established a graduate-level Program in Polymer Science and Technology (PPST). It is open to qualified students admitted to the graduate program(s) of one of the following four MIT departments: Chemical Engineering, Chemistry, Materials Science and Engineering, and/or Mechanical Engineering.

PPST consists of an initial academic phase in which all students participate (regardless of previous background and research interest); followed by research in a selected area of specialization. The program leads to the doctoral degree; if desired, a master’s degree can be obtained through the student’s home department.

The core curriculum, taken by all students, provides a common base in the field of polymers. It is broad, rigorous, and covers both elementary and advanced subjects spanning the entire range from the molecular level to the continuum. This curriculum takes up the first two terms in the graduate program.

The transition from the academic phase to research is marked by the qualifying exam, which consists of both oral and written sections. The exams are offered at the end of each spring term and are based on the PPST core curriculum. Successful completion of the exam leads to selection of a research project and the preparation and defense of a thesis proposal.

Any participating faculty member at MIT can act as a research supervisor. The thesis supervisor(s) advises the graduate student on a continuing basis throughout the time of the research project. Completion and successful defense of the thesis before PPST and departmental faculty fulfill the requirements for the doctoral degree.

For more information, including admission and financial aid procedures, contact the director, Professor Robert Cohen, Room 66-554, 617-253-3777, or visit http://web.mit.edu/ppst/.

System Design and Management Program
MIT’s System Design and Management (SDM) program, offered jointly by the School of Engineering and the MIT Sloan School of Management, is a master’s program for technical professionals seeking to build upon their backgrounds and experience in order to advance to positions of leadership in their profession.

The program leads to a Master of Science in Engineering and Management and represents a partnership of industry, government, and MIT for educating technically grounded leaders of 21st-century enterprises. It is MIT’s first degree program to be offered with a distance learning option in addition to a full-time in-residence option.

For additional information, see the program description under Engineering Systems Division or the Sloan School of Management in Part 2, or visit http://sdm.mit.edu/.
Technology and Policy Program
The Master of Science in Technology and Policy is an engineering research degree with a strong focus on the role of technology in policy formulation, analysis, and evaluation. The Technology and Policy Program (TPP) curriculum provides a solid grounding in technology and policy by combining advanced subjects in a student’s chosen technical field with courses in economics, politics, and law, and by requiring completion of a research thesis. To prepare participants for effective professional practice, TPP stresses effective leadership and communication. It also encourages students to participate in TPP’s summer internship program, which places students in government and industry in the United States and around the world.

Many students combine the TPP curriculum with complementary subjects to obtain dual degrees in TPP and either a specialized branch of engineering or an applied social science such as political science or urban studies and planning.

For additional information, see the program description under Engineering Systems Division in Part 2, or visit http://web.mit.edu/tpp/.
The field of computational and systems biology represents an integration of concepts and ideas from the biological sciences, engineering disciplines, and computer science. Recent advances in biology, including the human genome project and massively parallel approaches to probing biological samples, have created new opportunities to understand biological problems from a systems perspective. Systems modeling and design are well established in engineering disciplines but are relatively new to biology. Advances in computational and systems biology require multidisciplinary teams with skill in applying principles and tools from engineering and computer science to solve problems in biology and medicine. To provide education in this emerging field, the Computational and Systems Biology (CSB) program integrates MIT's world-renowned disciplines in biology, engineering, mathematics, and computer science. Graduates of the program will be uniquely prepared to make novel discoveries, develop new methods, and establish new paradigms. They will also be well-positioned to assume critical leadership roles in both academia and industry, where this field is becoming increasingly important.

Computational and systems biology, as practiced at MIT, is organized around “the 3 Ds” of description, distillation, and design. In many research programs, systematic data collection is used to create detailed molecular- or cellular-level descriptions of a system in one or more defined states. Given the complexity of biological systems and the number of interacting components and parameters, system modeling is usually conducted with the aim of distilling the essential or most important subsystems, components, and parameters, and of obtaining simplified models that retain the ability to accurately predict system behavior under a wide range of conditions. Distillation of the system can increase the interpretability of the models in relation to evolutionary and engineering principles such as robustness, modularity, and evolvability. The resulting models may also serve to facilitate rational design of perturbations to test understanding of the system or to change system behavior (e.g., for therapeutic intervention), as well as efforts to design related systems or systems composed of similar biological components.

More than 90 faculty members at the Institute participate in MIT’s Computational and Systems Biology Initiative (CSBI). These investigators span nearly all departments in the School of Science and the School of Engineering, providing CSB students the opportunity to pursue thesis research in a wide variety of different laboratories. It is also possible for students to arrange collaborative thesis projects with joint supervision from faculty members with different areas of expertise. Areas of active research include computational biology and bioinformatics, gene and protein networks, regulatory genomics, molecular biophysics, instrumentation engineering, cell and tissue engineering, predictive toxicology and metabolic engineering, imaging and image informatics, nanobiology and microsystems, biological design and synthetic biology, neurosystems biology, and cancer biology.

The CSB PhD program is an Institute-wide program that has been jointly developed by the Departments of Biology, Electrical Engineering and Computer Science, and Biological Engineering. The program integrates biology, engineering, and computation to address complex problems in biological systems, and CSB PhD students have the opportunity to work with CSBi faculty from across the Institute. The curriculum has a strong emphasis on foundational material to encourage students to become creators of future tools and technologies, rather than merely practitioners of current approaches. Applicants must have an undergraduate degree in biology (or a related field), chemistry, computer science, mathematics, statistics, physics, or an engineering discipline, with dual-emphasis degrees encouraged.

All students pursue a core curriculum that includes classes in biology and computational biology, along with a class in computational and systems biology based on the scientific literature. Advanced electives in science and engineering enhance both the breadth and depth of each graduate’s education. During their first year, in addition to coursework, students carry out rotations in research groups to gain a broader exposure to work at the frontier of this field, and to identify a suitable laboratory in which to conduct thesis research. CSB students also serve as teaching assistants during one semester in the second year to further develop their communication skills and to facilitate their interactions across disciplines. Students also participate in training in the responsible conduct of research to prepare them for the complexities and demands of modern scientific research. The total length of the program, including classwork, qualifying examinations, thesis research, and preparation of the thesis is roughly five years.

**Curriculum**

The CSB curriculum has two components. The first is a core that provides foundational knowledge of both biology and computational biology. The second is a customized program of electives that are selected by each student in close consultation with members of the CSB graduate committee. The goal is to allow students broad latitude in defining their individual area of interest, while at the same time providing oversight and guidance to ensure that training is rigorous and thorough.

**Core Curriculum**

The core curriculum consists of three classroom subjects plus a set of three research rotations in different research groups. The classroom subjects fall into three areas described below.

**Modern Biology (One Subject):** A term of modern biology at MIT strengthens the biology base of all students in the program. Subjects in cell biology, molecular biology, neurobiology, biochemistry, or genetics fulfill this requirement. The particular course taken by each student will depend on their background and will be determined in consultation with graduate committee members.

**Computational Biology (One Subject):** A term of computational biology provides students with a background in the application of computation to biology, including analysis and modeling of sequence, structural, and systems data. This requirement can be fulfilled by 7.91J/20.490J Foundations of Computational and Systems Biology.

**Topics in Computational and Systems Biology (One Subject):** All first-year students in the program participate in CSB.100J/7.89J Topics in Computational and Systems Biology, an exploration of problems and approaches in the field of computational and systems biology.
through in-depth discussion and critical analysis of selected primary research papers. This subject is restricted to first-year PhD students in CSB or related fields in order to build a strong community among the class. It is the only subject in the program with such a limitation.

Research Group Rotations (Three Rotations):
To assist students with lab selection and provide a range of research activities in computational and systems biology, students participate in three research rotations of one to two months’ duration during their first year. Students are encouraged to gain experience in experimental and computational approaches taken across different disciplines at MIT.

Advanced Electives
The requirement of four advanced electives is designed to develop both breadth and depth. The electives add to the base of the diversified core and contribute strength in areas related to student interest and research direction. To develop depth, two of the four advanced electives must be in the same research area or department. To develop breadth, at least one of the electives must be from an engineering discipline and at least one from biological sciences (including chemistry). Each student designs a program of advanced electives that satisfies the distribution and area requirements in close consultation with members of the graduate committee.

Additional Subjects: As is typical for students in other doctoral programs at MIT, CSB PhD students may take classes beyond the required diversified core and advanced electives described above. These additional subjects can be used to add breadth or depth to the proposed curriculum, and might be useful to explore advanced topics considered for the thesis research in later years. The CSB Graduate Committee will work with each graduate student to develop a path through the curriculum appropriate for his or her background and research interests.

Qualifying Exams: In addition to coursework and a research thesis, each student must pass a written and an oral qualifying examination at the end of the second year or the beginning of the third year. The written examination involves preparing a research proposal based on the student’s thesis research, and presenting the proposal to the examination committee. This process provides a strong foundation for the thesis, incorporating new research ideas and refinement of the scope of the research project. The oral examination is based on the coursework taken and on related published literature. The qualifying exams are designed to develop and demonstrate depth in a selected area (the area of the thesis research) as well as breadth of knowledge across the field of computational and systems biology.

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CSB Graduate Committee
Christopher Burge, PhD
Whitehead Career Development Professor of Biology
Chair of the Committee
Mark Bathe, PhD
Assistant Professor of Biological Engineering
Ernest Fraenkel, PhD
Associate Professor of Biological Engineering
Alan Davis Grossman, PhD
Praecis Professor of Biology
Amy E. Keating, PhD
Sizer Career Development Associate Professor of Biology
Aviv Regev, PhD
Burroughs Wellcome Fund Career Development Assistant Professor of Biology
Joel Voldman, PhD
Associate Professor of Electrical Engineering
Ron Weiss, PhD
Associate Professor of Computer Science and Biological Engineering
Forest White, PhD
Associate Professor of Biological Engineering
Jacob K. White, PhD
Cecil H. Green Professor of Electrical Engineering
Mehmet Fatih Yanik, PhD
Robert J. Shillman Career Development Associate Professor of Electrical Engineering
Founded in 1970, the Harvard-MIT Division of Health Sciences and Technology (HST) is one of the oldest and largest biomedical engineering and physician-scientist training programs in the United States and the longest-standing collaboration between Harvard and MIT.

HST’s unique interdisciplinary educational program brings engineering as well as the physical and biological sciences from the scientist’s bench to the patient’s bedside. Conversely, it brings clinical insight from the patient’s bedside to the laboratory bench. In this way, HST students are trained to have deep understanding of engineering, physical sciences, and the biological sciences, complemented with hands-on experience in the clinic or in industry; and they become conversant with the underlying quantitative and molecular aspects of medicine and biomedical science. Within HST, approximately 350 graduate students work with eminent faculty and affiliated faculty members from throughout the MIT and Harvard communities.

In addition to its outstanding record of accomplishment for research in human health care, HST educational programs are distinguished by three key elements:

- A strong quantitative orientation
- Required hands-on experience in a clinical setting
- A focused interdisciplinary research project

HST currently offers degrees in four multidisciplinary areas of graduate study:

- Master of Engineering in Biomedical Engineering
- Medical Sciences MD Program
- Medical Engineering and Medical Physics Doctoral Program
- Speech and Hearing Bioscience and Technology Doctoral Program

### MASTER’S PROGRAMS

#### Master of Engineering in Biomedical Engineering

The Master of Engineering (MEng) in Biomedical Engineering aims to educate students at the interface between engineering and biology or medicine, preparing them for leadership positions in the medical products, pharmaceutical, and biotechnology industries. The five-year program leads to a bachelor’s degree in a science or engineering discipline and a Master of Engineering in Biomedical Engineering. The program emphasizes engineering applications in systems physiology and clinical medicine; it is of particular value to students interested in applying biomedical engineering to the basic understanding of disease processes in the post-genomic era, and is designed for individuals desiring a medical and clinical focus in their careers.

Students take subjects that enable them to apply engineering expertise to problems in the medical and clinical sciences. Admission to HST’s MEng program is open only to current MIT undergraduate students and requires candidates to demonstrate adequate quantitative and engineering credentials through coursework as part of their undergraduate degree program. Students interested in applying should submit a standard MIT graduate application by the end of their junior year.

In addition to satisfying the undergraduate requirements of their departmental program, candidates also are expected to complete subjects in differential equations (18.03); organic chemistry (5.12); biochemistry (7.05 or 5.07); and one engineering transport or systems subject (e.g., 2.005, 3.185, 6.002, 10.310).

More detailed program objectives and the requirements can be found on the HST website, http://hst.mit.edu/.

### DOCTORAL PROGRAMS

#### Medical Sciences

HST’s Medical Sciences Program leads to the MD degree from Harvard Medical School. It 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, physicians, physical scientists, and engineers from the faculties of Harvard and MIT.

The programs of study are designed to meet the interests and needs of the individual student. The student is encouraged to pursue advanced study in areas of interest that may complement the subjects offered in HST. Such study may be undertaken as part of the MD degree requirements or may be pursued in a program that combines the MD with a master’s or doctoral degree. HST students join the students of the regular Harvard Medical School curriculum in the clinical clerkships.

Because HST is committed to educating physicians who have a deep understanding of the scientific basis of medicine and who are well equipped for an interdisciplinary research career, HST encourages students in the MD curriculum to devote time to research and requires a thesis for completion of the degree. Many MD students desire even more research training than is possible during the standard four-year MD curriculum. For such students, one option is to pursue a formal PhD program in addition to an MD program. Another option expands the MD program to five or more years in order to include a major research training component.

Further details on the Medical Sciences Program and application forms may be obtained from the Office of Admissions, Harvard Medical School, 25 Shattuck Street, Boston, MA 02115. Applications must be submitted by October 15 of the year before desired matriculation. For further information, candidates can contact HST’s medical sciences admissions coordinator at hst-md-admissions@mit.edu.
Medical Engineering and Medical Physics

The Medical Engineering and Medical Physics (MEMP) Program is a five-to-seven-year program that leads to the PhD in Medical Engineering and Medical Physics awarded by MIT or by the Harvard Faculty of Arts and Sciences. The program trains students as engineers or physical scientists who also have extensive knowledge of the medical sciences. By understanding engineering and physical science applications, as well as their clinical implications, graduates of this program are well positioned to define new questions and formulate novel approaches in biomedical research.

The MEMP program is founded on a philosophy of openness and collaboration, characteristics that encourage innovative and independent thinking and creativity. This philosophy is fostered by the unique environment in which MEMP students study. While each MEMP student has depth in one classical discipline of engineering or physical science, the collective community has students in all disciplines. MEMP students also have peers with diverse career paths in medicine, science, engineering, business, and government. This community promotes an open exchange of ideas and exposes students to different perspectives on the health sciences. Moreover, MEMP students have access to research opportunities in labs at Harvard, MIT, and the Harvard teaching hospitals. Students can do research with faculty at any of these institutions and have many opportunities through classes, events, and projects to interact with faculty from all of these institutions.

The program’s academic curriculum includes three phases that prepare students to be medical innovators who will advance human health. First, HST provides MEMP students with a thorough graduate education in a classical discipline of engineering or physical science. Each student selects a concentration area, such as mechanical engineering, chemistry and chemical engineering, materials science, electrical engineering, computer science, physics, aeronautics and astronautics, or nuclear engineering, and completes substantial coursework in this discipline. Students then become conversant in the biological sciences through preclinical coursework followed by a series of clinical experiences. They acquire a hands-on understanding of clinical care, medical decision making, and the role of technology in medical practice both in the classroom and in patient care. Because the interface of technology and clinical medicine represents a continuum that extends from the molecular to the whole-organism levels, MEMP offers two distinct but related curricular sequences in the biomedical sciences: the cellular and molecular medicine sequence and the systems physiology and medicine sequence.

Finally, MEMP students investigate important problems at the interfaces of science, technology, and clinical medicine through individualized research projects that prepare them to undertake independent research. MEMP students have the opportunity to perform thesis research in laboratories at MIT, Harvard, and the Harvard affiliated teaching hospitals.

Bioinformatics and integrative genomics (BIG), neuroimaging and bioastronautics are areas of specialization within MEMP for which HST offers specially designed training programs. MEMP candidates may choose to apply through MIT, Harvard, or both. Those applying to MEMP through MIT should submit a single application. Those applying to MEMP through Harvard must also apply to the School of Engineering and Applied Sciences or the Biophysics Program. Additional information about applying to MEMP is available at http://hst.mit.edu/public/admissions/.

Speech and Hearing Bioscience and Technology

HST’s doctoral program in Speech and Hearing Bioscience and Technology (SHBT), formerly Speech and Hearing Sciences, prepares students with an undergraduate background in science or engineering to have a broad acquaintance with the field of speech and hearing, and to develop specialized knowledge that focuses on a particular approach in research. The only program of its type in the country—and the only doctoral training program funded in this area by the National Institutes of Health—SHBT is designed to develop research scientists who can apply the concepts and methods of the physical and biological sciences to basic and clinical problems in speech and hearing using innovative research. No other research training program provides the multidisciplinary depth and breadth offered by SHBT. The five-to-seven-year program leads to a PhD in speech and hearing bioscience and technology from MIT. SHBT’s more than 50 participating faculty members represent 10 academic departments from Harvard and MIT, with research facilities at MIT, Harvard University, Harvard Medical School and affiliated teaching hospitals, and the Massachusetts Eye and Ear Infirmary (MEEI). The small class size of this unique program ensures personalized and high-quality training by a diverse and dedicated faculty from the two institutions.

SHBT’s curriculum provides an effective method of training researchers by introducing the physical and biological bases of speech and hearing mechanisms involved in the communications process. While SHBT seeks to develop research scientists rather than clinical practitioners, there is a strong emphasis on providing students with exposure to clinical problems, approaches, and techniques. Graduates are thoroughly prepared for successful careers in basic and applied research in industry, universities, or government laboratories involved with biological and synthetic communication systems.

Typically, a student’s first two years in the program are devoted to coursework, which is supplemented by significant exposure to various research projects. Courses in the first year assume familiarity with calculus and differential equations, college-level physics, probability and statistics, and biology. The core curriculum covers the anatomical, acoustical, physiological, perceptual, and cognitive basics, as well as the clinical approaches to speech and hearing problems. The early introduction of important concepts in acoustics, anatomy, and physiology provides a solid base from which to pursue individual research interests. Early in the curriculum, students are introduced to various research laboratories that use different approaches to solving speech and hearing problems. This involvement in research provides an immediate application of classroom subjects. Students work with research advisors to develop a thorough understanding of basic concepts and tools in their fields of concentration. Later, students participate in subjects that require them to apply basic concepts to clinical problems and scientific research. Throughout the curriculum,
special attention is devoted to developing personal integrity, scientific values, and scholarly practice. With faculty guidance, each student plans a concentration tailored to the student’s particular interest.

By the end of their second year, students identify an area of professional interest and choose a research project that forms the basis for their doctoral thesis. SHBT research in the speech and hearing sciences focuses on the biological and physical mechanisms underlying human communication by spoken language. The processes addressed by these sciences include the physical acoustics of sound and the perceptual neurophysiological bases of hearing, as well as the linguistic, cognitive, and motor levels of processing by talkers and listeners.

The SHBT training program is offered through HST to students who enrolled in fall 2011 and earlier. The program is formally transitioning and will be administered through Harvard Medical School’s Division of Medical Sciences effective fall 2012. Interested candidates should apply via DMS, not through HST. See http://www.hms.harvard.edu/dms/shbt/ for more information.

Inquiries
Additional information on degree programs, admissions, and financial aid can be obtained from HST’s Academic Office, Room E25-518, 617-253-7470.

The Harvard-MIT Division of Health Sciences and Technology is transitioning into the Institute for Medical Engineering and Science within the School of Engineering. Please consult the online catalog for updated information.

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MIT and the Woods Hole Oceanographic Institution (WHOI) on Cape Cod offer joint doctoral degrees in oceanography and doctoral, professional, and master’s degrees in oceanographic engineering.

Graduate study in oceanography encompasses virtually all of the basic sciences as they apply to the marine environment: physics, chemistry, geology, geophysics, and biology. Applied ocean science and engineering allows for concentration in the major engineering fields of civil and environmental, mechanical, and electrical engineering.

The graduate programs administered by joint MIT/WHOI committees draw from the faculty and staff of both institutions. Students accepted to the Joint Program have access to the extensive intellectual and physical resources available for advanced study at both Woods Hole and MIT.

The Joint Program involves several departments at MIT—Earth, Atmospheric, and Planetary Sciences and Biology in the School of Science; and Civil and Environmental Engineering; Electrical Engineering and Computer Science, and Mechanical Engineering in the School of Engineering.

Financial aid, offered as research assistantships or fellowships to most entering graduate students, is sufficient to cover tuition and fees and provide a stipend. Upon admission, students register in the appropriate MIT department and at WHOI simultaneously, and are assigned academic advisors at each institution. Because the Joint Program is not affiliated with any one particular MIT department, students who wish to be considered for the program must indicate their intent on the front of their applications.

Research at WHOI is devoted to using the basic sciences and engineering to gain a better understanding of the marine environment. Some 200 scientists and engineers and a support staff of about 600 work in laboratories located in the village of Woods Hole and on the nearby Quissett Campus. Another 75 people operate three research vessels (ranging from 177 to 279 feet in length), the deep-diving submersible ALVIN, and smaller coastal vessels. WHOI also has remotely-operated research vehicles and autonomous underwater vehicles. Computer services provided within WHOI include links to other institutions and to national networks.

A videoconferencing system between MIT and Woods Hole provides interactive transmission for classes, meetings, and other joint events. Specialized research facilities include the National Ocean Sciences Accelerator Mass Spectrometry Facility and the North-East Regional Ion Microprobe Facility. The library facilities shared with the Marine Biological Laboratory are supplemented by collections of the Northeast Fisheries Center of the National Marine Fisheries Service and the US Geological Survey’s Office of Marine Resources Branch of Atlantic Geology, all located in Woods Hole. The village is situated on the southwest corner of Cape Cod, about 80 miles from Boston.

Subjects, seminars, and opportunities for research participation are offered at both MIT and WHOI. Place of residence is determined by the student’s selected program of study and research interests, and transportation is provided between institutions. Students have the opportunity to participate in oceanographic cruises during graduate study.

The faculty of MIT, together with the WHOI scientific staff, offer a wide variety of formal and informal subjects in various aspects of oceanography and areas directly applicable to ocean science and engineering; both faculties are equally involved in all levels of instruction. The subjects are supplemented by numerous seminars, directed studies, and cross-registration privileges with Harvard, Brown, and the Boston University Marine Program. Complete listings can be found in the subject descriptions of each individual department.

### Chemical Oceanography

Chemical oceanographers study the chemical composition of the marine environment and the processes that have produced the present composition of sea water and sediments. Principal research areas include water column geochemistry, sedimentary geochemistry, seawater-basalt interactions, and atmospheric chemistry. The departments of Earth, Atmospheric, and Planetary Sciences and Civil and Environmental Engineering offer programs with WHOI in chemical oceanography and marine geochemistry. These programs lead to the Doctor of Science or Doctor of Philosophy.

### Marine Geology and Geophysics

The goal of Marine Geology and Geophysics is to understand the physical and chemical processes that determine the structure and evolution of the ocean basins and their margins. Research is being conducted in a wide range of specialties including micropaleontology, paleoceanography, petrology and volcanic processes, seismology, gravity, magnetics, heat flow, sediment dynamics, and isotope geology. The Department of Earth, Atmospheric, and Planetary Sciences at MIT offers programs with WHOI in marine geology and geophysics which lead to the Doctor of Science or Doctor of Philosophy.

### Biological Oceanography

Biological oceanography seeks to describe and understand the biological processes which are active in the marine and bordering environments. The research of biological oceanographers is diverse, including ecology, toxicology, biochemistry, animal behavior and physiology, and molecular biology. The programs in biological oceanography are coordinated by the Department of Biology and WHOI, and may involve research in other MIT departments such as the Department of Civil and Environmental Engineering. The programs lead to the Doctor of Science or Doctor of Philosophy.
Applied Ocean Science and Engineering

Applied ocean science and engineering involves the application of physics and the engineering sciences to the study of oceanic processes and the design of instruments, systems, and structures required to observe, measure, and work in the ocean. The departments of Civil and Environmental Engineering, Electrical Engineering and Computer Science, and Mechanical Engineering offer joint programs with WHOI in oceanographic engineering. The programs lead to the master’s degree, engineer’s degree, Doctor of Science, or Doctor of Philosophy.

Inquiries

Application for admission to the Joint Program in Oceanography and Applied Ocean Science and Engineering with the Woods Hole Oceanographic Institution should be made on the MIT graduate application form, which may be obtained from the Graduate Admissions Office at MIT. Requests for further information may be addressed to the MIT/WHOI Joint Program, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, 508-289-2219, or to the MIT Joint Program Office, Room 54-911, 617-253-7544. More information is available at http://mit.whoi.edu/.
The study of microbes has been critical in our current understanding of basic biological processes, evolution, and the functions of the biosphere, and has contributed to numerous fields of engineering. Microbes have the amazing ability to grow in extreme conditions, to grow slowly or rapidly, and to readily exchange DNA. They are essential for life as we know it, but can also be agents of disease. They are instrumental in shaping the environment, in evolution, and in modern biotechnology. Microbes are amenable to virtually all modern approaches in science and engineering. As such, they provide natural engineering laboratories for creating new capabilities for industry (e.g., pharmaceuticals, chemicals, energy) and are the foundation of pioneering efforts in synthetic biology, i.e., building life from its component parts. Effective study of microbes and their applications demands multiple interdisciplinary approaches that cross all scales of biological organization, from molecules to vast ecosystems.

Research in microbiology is going on throughout MIT and involves more than 50 faculty. These faculty are from several departments in both the Schools of Science and Engineering, including Biology; Biological Engineering; Chemical Engineering; Chemistry; Civil and Environmental Engineering; Earth, Atmospheric and Planetary Sciences; Electrical Engineering and Computer Science; Materials Sciences and Engineering; and Physics. Many labs take multiple approaches to studying and manipulating microbial systems and the expertise and research covers a wide range of areas, including biochemistry, biotechnology, cell and molecular biology, chemical and biological engineering, computational biology, ecology, environmental biology, evolutionary biology, genetics, genomics, geobiology, immunology, pathogenesis, structural biology, synthetic biology, systems biology, and virology.

The Graduate Program in Microbiology—a new, interdepartmental, and interdisciplinary initiative at MIT—integrates educational resources across the participating departments to build connections among faculty with shared interests and to build an educational community for training students in the study of microbial systems.

Interdisciplinary training in microbiology is in increasing demand in both public and private sectors. This program provides a broad exposure to underlying elements of modern microbiological research and engineering as well as in-depth research experience in specific areas of microbiology. Program graduates will be prepared to work in a range of fields in microbial science and engineering, and will have excellent career options in academia, industry, and government.

## Curriculum

The major components of the training program are required coursework, elective coursework, rotations and thesis research, teaching, training in the ethical conduct of research, and qualifying exams.

### Required Subjects

<table>
<thead>
<tr>
<th>Code</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.492J</td>
<td>Methods and Problems in Microbiology</td>
</tr>
<tr>
<td>7.493J</td>
<td>Microbial Genetics and Evolution</td>
</tr>
<tr>
<td>7.499</td>
<td>Research Rotations in Microbiology</td>
</tr>
<tr>
<td>7.57</td>
<td>Quantitative Biology for Graduate Students</td>
</tr>
<tr>
<td></td>
<td>One of the following biochemistry subjects:</td>
</tr>
<tr>
<td>7.51</td>
<td>Principles of Biochemical Analysis or</td>
</tr>
<tr>
<td>7.80</td>
<td>Biological Chemistry II</td>
</tr>
</tbody>
</table>

### Elective Subjects

Students must take three elective subjects, totaling 36 units, from the following list. Electives can be chosen to provide depth in a specific area of interest or additional breadth in training. Subjects from some other areas may also fulfill the requirement, with the approval of the Graduate Education committee.

<table>
<thead>
<tr>
<th>Code</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.89</td>
<td>Environmental Microbiology</td>
</tr>
<tr>
<td>5.062</td>
<td>Principles of Bioinorganic Chemistry</td>
</tr>
<tr>
<td>5.451</td>
<td>Chemistry of Biomolecules and Natural Product Pathways</td>
</tr>
<tr>
<td>5.50</td>
<td>Enzymes: Structure and Function</td>
</tr>
<tr>
<td>5.52</td>
<td>Advanced Biological Chemistry</td>
</tr>
<tr>
<td>5.55</td>
<td>Chemical Tools for Assessing Biological Function</td>
</tr>
<tr>
<td>5.64</td>
<td>Biophysical Chemistry</td>
</tr>
<tr>
<td>5.65</td>
<td>Molecular Imaging</td>
</tr>
<tr>
<td>5.78</td>
<td>Biophysical Chemistry Techniques</td>
</tr>
<tr>
<td>6.874</td>
<td>Computational Systems Biology</td>
</tr>
<tr>
<td>7.26/7.66</td>
<td>Molecular Basis of Infectious Disease</td>
</tr>
<tr>
<td>7.56</td>
<td>Foundations of Cell Biology</td>
</tr>
<tr>
<td>7.58</td>
<td>Molecular Biology</td>
</tr>
<tr>
<td>7.62</td>
<td>Microbial Physiology</td>
</tr>
<tr>
<td>7.63</td>
<td>Immunology</td>
</tr>
<tr>
<td>7.70</td>
<td>Regulation of Gene Expression</td>
</tr>
<tr>
<td>7.75/5.771</td>
<td>Topics in Metabolic Biochemistry</td>
</tr>
<tr>
<td>7.91/20.490</td>
<td>Foundations of Computational and Systems Biology</td>
</tr>
<tr>
<td>8.591/7.81</td>
<td>Systems Biology</td>
</tr>
<tr>
<td>10.542</td>
<td>Biochemical Engineering</td>
</tr>
<tr>
<td>10.544</td>
<td>Metabolic and Cell Engineering</td>
</tr>
<tr>
<td>10.546J/5.70/20.465</td>
<td>Statistical Thermodynamics with Applications to Biological Systems</td>
</tr>
<tr>
<td>10.977</td>
<td>Advances in Bioinformatics and Metabolic Engineering</td>
</tr>
<tr>
<td>20.106J</td>
<td>Systems Microbiology</td>
</tr>
<tr>
<td>20.440</td>
<td>Analysis of Biological Networks</td>
</tr>
<tr>
<td>20.450</td>
<td>Molecular and Cellular Pathophysiology</td>
</tr>
<tr>
<td>20.485</td>
<td>Tools for Assessing Biological Function</td>
</tr>
<tr>
<td>HST.508</td>
<td>Quantitative Genomics</td>
</tr>
</tbody>
</table>

### Rotations and Thesis Research

During the first year, students will rotate through three labs of MIT faculty that participate in the Microbiology Graduate Program. These rotations will help provide students broad exposure to microbiology research and will be used to select a lab for their thesis research by the end of the first year. Given the interdisciplinary nature of the program and many research programs, students may be able to work jointly with more than one research supervisor.

### Teaching Experience

Learning to effectively communicate scientific ideas is an important skill. Students in the Microbiology program will have an opportunity to improve their communication skills through teaching. Each student will serve as a teaching assistant for one term in an undergraduate or graduate subject related to microbiology. This will typically take place in the second year.
Training in the Ethical Conduct of Research
All students will participate in a course on the ethical conduct of research. This will typically take place during the first year.

Qualifying Exams
Students will proceed to PhD candidacy after successful completion of a qualifying exam, typically during the second year. Students will submit a written research proposal in the style of a grant or fellowship application based on their planned thesis project. Students will then present and discuss the research proposal with a small committee of faculty.

STUDENT ADVISING
In the first year, students will be advised by members of the graduate committee. Once students join a thesis lab, the research mentor will be the primary advisor. Early in the second year, students will form a thesis committee and meet at least annually. The committee will consist of faculty with expertise in the student’s area of research and collectively provide the breadth expected by the program. The thesis committee will primarily provide advice on research. In addition, in the student’s early years the thesis committee will also provide advice on coursework to ensure that students have the appropriate breadth and depth for their educational program. In later years, the graduate and thesis committees will also provide students with advice on career options.

FINANCIAL SUPPORT AND FELLOWSHIPS
Students in the program will be financially supported throughout their training. This support includes tuition, stipend, and health insurance. All students in the program will receive a stipend that is sufficient to support living in the Cambridge/Boston area. The stipend will be approximately the same as for graduate students in other MIT departments.

During the first year, students are supported by the Microbiology program. In subsequent years, students will be supported as research assistants in their thesis lab. Although students will be supported, they are strongly encouraged to apply for fellowships.

INQUIRIES
For further information about the Graduate Program in Microbiology, contact Bonnie Lee Whang, Room 68-139, microbiology@mit.edu, or visit http://microbiology.mit.edu/.
MIT provides students with a broad range of opportunities for transportation-related education. Courses and classes span the School of Engineering, the Sloan School of Management, and the School of Architecture and Planning, with many activities covering interdisciplinary topics that prepare students for future industry, government, or academic careers.

A variety of graduate degrees are available to students interested in transportation studies and research, including a master's program and a doctoral program in transportation, described below, and a Master of Engineering in Logistics, described under Engineering Systems Division in Part 2.

Opportunities are also available for students to obtain dual master's degrees. Students who wish to pursue this option must follow the regular admissions procedure to be admitted to each degree program. Common dual degree pairings include the Master of Science in Transportation with:

- Master of Science in Technology and Policy
- Master of Science in Operations Research
- Master of City Planning

Information on requirements for dual degrees can be found in the section on General Degree Requirements in Part 1.

**MASTER OF SCIENCE IN TRANSPORTATION**

The Master of Science in Transportation (MST) program is based on the premise that a common set of analytical approaches and methodologies can be applied to solve a range of transportation problems. The MST provides a common basis for addressing a wide range of problems while allowing enough flexibility to accommodate students with diverse backgrounds and interests.

Students in the MST program must complete 66 units of coursework plus a master's thesis; coursework includes two required core subjects and at least three additional transportation or related subjects. Generally, the three additional subjects relate to an area of specialization, although this is not required. Common areas of specialization include urban transportation, air transportation, planning methods, logistics, and policy. The MST degree usually takes up to two years to complete.

**Course Requirements**

**Core Subjects**

Two 12-unit subjects that reflect the interdisciplinary, systems nature of the program's educational approach, offered in the fall term:

1.200 Transportation Systems Analysis: Performance and Optimization
1.201 Transportation Systems Analysis: Demand and Economics

**Individually Designed Program**

Three subjects totaling at least 30 units, selected by the student to further his or her educational objectives in the field of transportation. Established program areas include:

- Air transportation
- Transportation analysis and planning methods
- Transportation logistics
- Transportation management
- Transportation policy
- Urban transportation

Specific subjects approved for these program areas are listed at [http://cee.mit.edu/graduate/transportation/areas/](http://cee.mit.edu/graduate/transportation/areas/). Some students use the individually designed program to deepen their understanding of a selected area of interest, others may choose to emphasize breadth rather than depth in their studies.

For all students, at least one of the selected subjects should address policy. At least two of the designated subjects should be clearly focused on transportation, while the third can be in a field that supports transportation, for example, a subject covering methods used in transportation drawn from fields such as economics, operations research, political science, or management.

**Policy Requirement**

To fulfill the policy requirement, students can choose a transportation policy subject, a transportation subject with substantial policy content (nominally half), or a policy subject with little or no transportation content. A list of subjects that meet these criteria can be found at [http://cee.mit.edu/graduate/transportation/degreerequirements/](http://cee.mit.edu/graduate/transportation/degreerequirements/).

**Information Technology Requirement**

Graduates of the MST program are expected to have a working knowledge of information technology, as this is a prerequisite for functioning as a transportation professional. The information technology requirement can be satisfied by taking either 1.264J Database, Internet, and Systems Integration Technologies (recommended for most students) or 1.001 Introduction to Computers and Engineering Problem Solving. Requests to waive this requirement based on prior coursework must be submitted in writing to the director of the MST Program.

**Thesis Requirement**

Students must complete a research-based thesis on a topic of their choice that has been approved by the thesis supervisor. Students should enroll in the minimum requirement of 24 (1.7G) thesis units. Thesis units do not count toward the 66 units required for completion of the MST degree.

For more information, see the full MST program description at [http://cee.mit.edu/graduate/mst/](http://cee.mit.edu/graduate/mst/).

**Admission**

An undergraduate degree in engineering is not necessary for admission to the Master of Science in Transportation program, but applicants are expected to have an aptitude for analytical thinking. Backgrounds in the physical or social sciences, urban planning, management, and many other disciplines are equally appropriate foundations for the program.

The only specific subjects required for admission are two subjects in calculus: one in economics and one in probability. One or more of these subjects may be completed simultaneously with application to the program, and acceptance is then conditional on satisfactory completion of these prerequisites. Applicants...
should have roughly the equivalent of the following MIT subjects: 18.01 and 18.02 in calculus, 14.01 in microeconomics, and either 6.041 or 1.010 in probability/statistics.

All applicants are required to submit Graduate Record Examination (GRE) scores; applicants whose native language is not English are required to submit a Test of English as a Foreign Language (TOEFL) score. Applicants to the Master of Science in Transportation degree program must achieve a score of at least 250 (computer-based) on the TOEFL.

**FUNDING**

Funding for MST students is usually offered to about 80 percent of each incoming class. A limited number of fellowships are offered each year, but more often funding takes the form of a research assistantship (RA). A student with RA funding typically works with a faculty member on a research project for 15–30 hours a week. The research that is conducted on that project generally becomes the topic of the student’s thesis.

To learn more about current transportation research at MIT, visit [http://cee.mit.edu/research/transportation/](http://cee.mit.edu/research/transportation/), [http://cee.mit.edu/research/projects#transportation](http://cee.mit.edu/research/projects#transportation), and [http://cee.mit.edu/research/projects#or](http://cee.mit.edu/research/projects#or).

Funding for RAs is awarded as either a half or full appointment. An award of a full RA (about 30 hours of work per week) covers the student’s tuition for the academic year and provides a monthly stipend to cover living expenses. A half RA (approximately 15 hours of work per week) covers half of the student’s tuition for the academic year and provides half of the regular monthly stipend.

Students who are not awarded financial aid at the time of admission may seek funding through other sources.

**DOCTOR OF PHILOSOPHY IN TRANSPORTATION**

The interdisciplinary doctoral program in transportation provides a structured and direct follow-on doctoral program for students enrolled in the Master of Science in Transportation or other transportation-related master’s degree programs offered at MIT or elsewhere. The interdisciplinary structure allows students great flexibility in developing individual programs of study that cross both disciplinary and departmental lines. The program is administered by a faculty committee responsible for admissions, establishment and oversight of program requirements, and conduct of the general examination and dissertation defense.

The interdisciplinary doctoral program in transportation requires completion of at least 150 units of coursework in a program of study proposed by the student, the successful completion of a general examination consisting of both written and oral components, and the submission and defense of an acceptable dissertation. The program of study includes a doctoral core program consisting of at least 66 units that represent the student’s area of specialization. At least two of the core subjects should be methodological subjects and two should be transportation subjects.

Graduates of the interdisciplinary doctoral program receive a PhD in Transportation, although students may petition for other MIT graduate fields of study as their degree designation, subject to approval by the Transportation Graduate Program Committee.

**INQUIRIES**

Questions about and applications to graduate programs in transportation should be directed to the MST program director, Department of Civil and Environmental Engineering, Room 1-290.
Interdisciplinary research can be an invaluable way to broaden a student’s education. Through the Undergraduate Research Opportunities Program, undergraduates discover avenues for participation in research projects that can count toward their major, including possibilities for thesis work. The interdisciplinary programs and facilities described in this section also provide significant opportunities for graduate students.

### MIT Centers, Labs, and Programs

- Center for Archaeological Materials
- Center for Biomedical Engineering
- Center for Collective Intelligence
- Center for Computational Engineering
- Center for Computational Research in Economics and Management Science
- Center for Energy and Environmental Policy Research
- Center for Environmental Health Sciences
- Center for Global Change Science
- Center for International Studies
- Center for Materials Science and Engineering
- Center for Real Estate
- Center for Transportation and Logistics
- Computer Science and Artificial Intelligence Laboratory
- Deshpande Center for Technological Innovation
- Division of Comparative Medicine
- Francis Bitter Magnet Laboratory
- Haystack Observatory
- Institute for Medical Engineering and Science
- Institute for Soldier Nanotechnologies
- Institute for Work and Employment Research
- Joint Program on the Science and Policy of Global Change
- Knight Science Journalism Program
- Koch Institute for Integrative Cancer Research
- Laboratory for Financial Engineering
- Laboratory for Information and Decision Systems
- Laboratory for Manufacturing and Productivity
- Laboratory for Nuclear Science
- Lean Advancement Initiative
- Legatum Center for Development and Entrepreneurship
- Lincoln Laboratory
- Martin Trust Center for MIT Entrepreneurship
- Materials Processing Center
- McGovern Institute for Brain Research
- Media Lab
- Microsystems Technology Laboratories
- Middle East Program at MIT
- MIT Catalyst Clinical Research Center
- MIT Center for Art, Science, and Technology
- MIT Center for Digital Business
- MIT Energy Initiative
- MIT Kavli Institute for Astrophysics and Space Research
- MIT Portugal Program
- MIT Professional Education
- MIT Program in Art, Culture and Technology
- MIT Sea Grant College Program
- Nuclear Reactor Laboratory
- Operations Research Center
- Picower Institute for Learning and Memory
- Plasma Science and Fusion Center
- Research Laboratory of Electronics
- Simons Center for the Social Brain
- Singapore-MIT Alliance
- Singapore-MIT Alliance for Research and Technology
- Sociotechnical Systems Research Center
- Spectroscopy Laboratory
- Technology and Development Program
- Transportation@MIT
- Women’s and Gender Studies Program
- Broad Institute of MIT and Harvard
- Draper Laboratory
- Whitehead Institute for Biomedical Research
MIT CENTERS, LABS, AND PROGRAMS

Many undergraduates find opportunities to participate in the research activity of MIT’s interdisciplinary centers, laboratories, and programs through the Undergraduate Research Opportunities Program. For graduate students, interdisciplinary research opportunities can often lead to thesis topics—and research assistantships—as well as advanced degrees.

Some interdepartmental educational programs have been approved for graduate students by the Committee on Graduate Programs. Students must be admitted by a regular academic department in order to participate in one of these programs (with the exception of the Operations Research Center, which accepts students directly). Each has a standing faculty committee that administers the program, but degrees in the field of study are granted by the student’s department of registration. The program descriptions in this section indicate any advanced degrees that may be offered.

Center for Archaeological Materials

The purpose of the center is to encourage incorporation of the natural sciences and engineering in the normal pursuit of anthropological, archaeological, and art historical inquiry.

The center’s particular emphasis is on examining and explaining the nature of prehistoric and non-industrial technologies, especially those technologies of unusual importance in the development of ancient and pre-industrial societies. The center considers not only technologies of subsistence, communication, and production, but technologies whose purposes are largely symbolic, such as information-bearing technologies of art.

The center is concerned with the remains of human activities in the past and the exploration of the imprint of these activities on the environment: what people did in the environment and what the environment was like. Determination of palaeocologies—climates, floral and faunal populations, food chains, and so forth—provides a strong research focus. The center uses as its evidence all of material culture, and explores cultural and environmental materials through the most up-to-date methods common to chemistry, physics, biology, geology, and materials science and engineering, in conjunction with appropriate mathematical and statistical analyses.

The center’s teaching and research programs incorporate materials science and engineering among the range of methods that archaeologists use to try to render culture history, cultural lifeways, and culture process from what little is preserved of society’s material culture. Research activities are carried out in a network of materials laboratories that include metallurgy, ceramics, photomicrography, and computation. The center emphasizes rigorous laboratory study of artifacts and other kinds of cultural remains to determine the nature and structure of the materials of which they are composed and the extraction and processing regimes they have undergone.

Open to graduate students and senior undergraduates, the center offers graduate-level subjects in the Graduate Archaeological Science Laboratory. Subjects are heavily laboratory-oriented and often cover a single class of materials (e.g., ceramics or metals), or a method for interpreting archaeological data (e.g., computers in archaeology).

The Center for Archaeological Materials is administered by the Office of the Provost. Further information about the center may be obtained from the director, Professor Heather Lechtman, Department of Materials Science and Engineering, Room 8-138, 617-253-1375.

http://web.mit.edu/cmrae/cmrae_home.htm

Center for Biomedical Engineering

The Center for Biomedical Engineering (CBE) was established to enhance and coordinate research and education at the interface of engineering with biology, emphasizing bioengineering based on molecular and cellular biology.

CBE initiatives involve faculty and students from a variety of MIT departments in the Schools of Science and Engineering along with associates at Boston-area medical schools.

Core laboratory facilities in real-time PCR, biomolecular modeling and engineering, biomolecular binding interactions, cell and molecular mechanics, cellular responses, cell culture, 2-photon microscopy, and quick freeze-deep etch cryofixation facilities for cells and tissues are available to enhance teaching and research capabilities that combine engineering and life science perspectives. For further information on these facilities, contact Linda Bragman, 617-253-4928.

CBE’s Industrial Advisory Board includes representatives from member companies from the bioengineering and health care community and provides an interface for student recruiting into the bioengineering industrial community.

http://web.mit.edu/cbe/www/

Center for Collective Intelligence

The MIT Center for Collective Intelligence brings together faculty from across MIT to conduct research on how new communications technologies, especially the internet, now allow huge numbers of people all over the planet to work together in new ways. The center’s basic research question is: How can people and computers be connected so that—collectively—they act more intelligently than any individuals, groups, or computers have ever done before?

This first-of-its-kind research effort draws on the strengths of many diverse organizations across MIT including the MIT Media Lab, the Computer Science and Artificial Intelligence Laboratory, the Department of Brain and Cognitive Sciences, and the MIT Sloan School of Management.

The Center for Collective Intelligence is directed by Professor Thomas W. Malone. For further information, contact Robert Halperin, 617-253-4413, rrhalp@mit.edu.

http://cci.mit.edu/

Center for Computational Engineering

The broad mission of the Center for Computational Engineering (CCE) is to support computational engineering at MIT. The center is comprised of faculty and research partners from across the School of Engineering as well as other departments and units involved in computational engineering (CE) research and education around the Institute.

Our research focus is on computational approaches for engineering problems, the formulation and implementation of new approaches that are more efficient and capable, and the informed application of existing approaches to important engineering questions. Our emphasis is on the development of the “next generation” of CE innovators and CE innovations. CCE oversees a master’s program in Computation for Design and Optimization. This is an interdisciplinary program that provides students...
with a strong foundation in computational methods for the design and operation of complex engineered and scientific systems.

For more information about the Center for Computational Engineering, contact Debra Blanchard, Room 3-264, 617-258-5808, ddblnc@mit.edu. For more information about the Computation for Design and Optimization program, contact Barbara Lechner, Room 35-329, 617-253-3725, cdo_info@mit.edu.

http://computationalengineering.mit.edu/

Center for Computational Research in Economics and Management Science
This center advances knowledge about modeling in economics, finance, statistics, and management, bringing together researchers from disciplines such as econometrics, statistics, computer science, and operations research to focus on the algorithmic research and related software development that provide a basis for today’s advanced modeling techniques. Current research is focused on predictive data analytics; nonparametric modeling; robust statistics and data-mining; statistical learning; variable and feature selection; risk measurement and portfolio optimization in finance, data visualization, bioinformatics; and the analysis of health and drug surveillance data.

For further information contact Professor Roy E. Welsch, director, Room E62-564, 617-253-6601, rwelsch@mit.edu.

Center for Energy and Environmental Policy Research
The Center for Energy and Environmental Policy Research (CEEPR) conducts policy-related research in energy and environmental economics, drawing on faculty and student resources from the Sloan School of Management, the MIT Department of Economics, and the MIT Energy Initiative. CEEPR also collaborates with engineers and scientists as a co-sponsor of the Joint Program on the Science and Policy of Global Change, along with the MIT Center for Global Change Science.

The center’s distinguishing characteristic is its dedication to high-quality, empirically-grounded economic analysis of corporate and public policy issues. For over 30 years, CEEPR has made important contributions to the analysis of energy markets, the organization and regulation of energy industries, and environmental problems. CEEPR’s current research focuses on emissions markets; electric utility restructuring; investment, finance, and risk management in energy and environmental projects; human welfare and the environment; and the effectiveness of environmental regulation. The results of the research are disseminated through publications, workshops, educational programs and public outreach activities around the world.

Professor Richard Schmalensee, of the MIT Sloan School of Management, is the center’s director. For more information, contact the executive director, John Parsons, E19-411, 617-324-3745, jparsons@mit.edu.

http://web.mit.edu/ceapr/www/

Center for Environmental Health Sciences
The Center for Environmental Health Sciences (CEHS) applies a broad range of cutting-edge technologies to the goal of studying the biological effects of exposure to environmental agents in order to understand, and predict, how such exposures affect human health.

CEHS is funded by the National Institute of Environmental Health Sciences. Its research programs, organized in five research themes, pose challenging interdisciplinary problems for graduate and undergraduate students working with 39 CEHS members of MIT, Harvard University, and local area hospitals.

The five research themes are: DNA damage, DNA repair, and mutagenesis; inflammation chemistry and biology; microbes and disease susceptibility; bioengineering for toxicology; and exposure and response. These research activities are supported by four facilities cores—Bioanalytical, Genomics and Imaging, Animal Models, and Integrative Health Sciences—that provide state-of-the-art tools and technologies for solving environmental health problems.

At MIT, graduate and undergraduate courses in molecular and systems toxicology are offered through the Department of Biological Engineering; CEHS also partners with many departments in the Schools of Science and Engineering to create cross-disciplinary opportunities in environmental health science and engineering. The Applied Biosciences PhD program based in the Department of Biological Engineering integrates chemistry, molecular biology, and genetics with bioengineering approaches to the understanding of how organisms respond to environmental agents.

For further information, please contact the center at 617-253-6224 or cehs@mit.edu.

http://cehs.mit.edu/

Center for Global Change Science
The MIT Center for Global Change Science (CGCS) seeks to better understand the natural mechanisms in ocean, atmosphere, and land systems that together control the Earth’s climate, and to apply improved knowledge to problems of predicting climate changes. The center utilizes theory, observations, and numerical models of the Earth’s basic physical and biogeochemical processes to investigate climate phenomena, the linkages among them, and their potential feedbacks in a changing climate.

CGCS was founded in 1990 to foster cooperative effort among faculty, students, and research scientists in meteorology, oceanography, hydrology, atmospheric sciences, climate physics, chemistry, biology, ecology, and satellite remote sensing. Participants are drawn primarily from the departments of Earth, Atmospheric and Planetary Sciences; Civil and Environmental Engineering; Biology; and Electrical Engineering and Computer Science.

The major research initiatives in CGCS are the MIT Climate Modeling Initiative (CMI), the Advanced Global Atmospheric Gases Experiment (AGAGE), and the MIT Joint Program on the Science and Policy of Global Change (described later in this chapter). Through the latter, CGCS sustains substantial collaborative effort with faculty, students, and researchers in Economics, Political Science, Urban Studies and Planning, the Sloan School of Management, Engineering Systems, and the MIT Energy Initiative.

CMI is an open-source collaborative that has developed the MIT General Circulation Model (MItcgm) which is applied to a wide range of
modeling challenges in: atmospheres, oceans, the cryosphere, biogeochemical cycles, ocean ecology and the coupling together of all these processes.

AGAGE measures greenhouse gases globally and infers their sources and sinks using inverse methods. It is distinguished by its capability to measure over the globe at high frequency almost all of the important gas species in the Montreal Protocol (e.g., CFCs, HCFCs) to protect the ozone layer and almost all of the significant non-CO2 gases in the Kyoto Protocol (e.g., HFCs, methane, and nitrous oxide) to mitigate climate change.

Professor Ronald Prinn is the CGCS director. For more information, contact CGCS at Room 54-1312, 617-253-4902, cgcs@mit.edu. http://cgcs.mit.edu/

Center for International Studies
The Center for International Studies (CIS) supports and promotes international research and education at MIT.

CIS includes 100 members of the MIT faculty and staff, mainly drawn from the departments of Political Science and Urban Studies and Planning, and visiting scholars from around the world. We sponsor formal programs, interdisciplinary working groups and numerous public events. While CIS does not offer courses, students engage with the center’s faculty and staff as colleagues in research, dissertation students, participants in a range of events, and enthusiastic interns in the MIT Science and Technology Initiative (MISTI), the groundbreaking international education program. The center also provides other services to MIT students: internships, other opportunities to work in programs, and help with finding resources for research.

Within CIS is the MIT Security Studies Program (SSP), a graduate-level research and educational program. SSP’s teaching ties are with the Political Science Department. Courses offered emphasize grand strategy, the causes and prevention of international and civil conflict, military technology, nuclear proliferation, bureaucratic politics, national security, budgetary issues, and security issues in Asia. A special feature of the program is the integration of knowledge on technology with knowledge from the social sciences in the study of international security problems. SSP’s primary task is educating the next generation of security scholars and practitioners.

For more information on SSP, contact Joli Divon Saraf, Room E40-428, 617-253-8488, fax 617-253-8858, joli@mit.edu.

The MIT International Science and Technology Initiatives, better known as MISTI, connects MIT students and faculty with research and innovation around the world. MISTI’s primary international program, MISTI is a pioneer in applied international studies. Through country programs in Brazil, Chile, China, France, Germany, India, Israel, Italy, Japan, Korea, Mexico, Russia, Singapore, and Spain, MISTI matches more than 600 MIT students with internships and research abroad each year in companies, research labs, and universities. MISTI Global Seed Funds provide funding for faculty to jump-start international projects and encourage student involvement in faculty-led international research.

For more information, contact the program at Room E40-428, 617-258-0385, or visit http://web.mit.edu/misti/.

Seminar XXI is an educational program for senior military officers, government and NGO officials, and executives in the national security policy community. The program’s objective is to provide future leaders of that community with enhanced analytic skills for understanding foreign countries and the relations among them. The fundamental criterion for fellows is that candidates should reach top decision-making levels in the next three to five years.

The program explores key policy issues by examining countries and problems critical to American interests through a variety of paradigmatic lenses.

For more information, contact Tisha Gomes, Room E40-445, 617-258-6862, fax 617-258-7044, tishag@mit.edu.

The Program on Human Rights and Justice, an interdisciplinary program created by CIS and the Department of Urban Studies and Planning, focuses on teaching, research, and application in human rights, and provides a forum on human rights issues at MIT. The activities of the program include research projects and placing interns in intergovernmental organizations, private sector, and nongovernmental organizations worldwide.

For more information, contact phi@mit.edu.

The Inter-University Committee on International Migration, created 30 years ago, organizes the Myron Weiner seminar series, honoring the late MIT professor and pioneer in migration studies. The committee also undertakes other projects on an ad hoc basis. Member institutions are Boston University, Brandeis University, the Fletcher School of Law and Diplomacy, Harvard, MIT, Tufts University, and Wellesley College. The committee is hosted at MIT by CIS.

For more information, email cis-migration@mit.edu.

The Program on Emerging Technologies (PoET) is a collaborative effort between the School of Engineering and the School of Humanities, Arts, and Social Sciences. Researchers at the Center for International Studies work together with colleagues from the Engineering Systems Division, the Technology and Policy Program, the Department of Political Science, and the Program in Science, Technology, and Society. With current, future, and historical focuses, research efforts address diverse implications of emerging technologies and how responses to anticipated policy or societal impacts may shape the way in which those technologies are developed.

For more information, contact Sarah Jane Vaughan, E40-450, 617-253-3848, fax 617-253-9330, svaughan@mit.edu.

Persian Gulf Initiative was launched in 2005 and has now held workshops on political violence, stability and legitimacy, energy security, the regional impacts of the Iraq war, and other topics. It sponsors research such as the Iraq mortality study, publications, and public forums, several of which have been held in Washington, DC, and New York.

For more information, contact Casey Johnson, E40-451, 617-258-8550, caseyj@mit.edu.

CIS manages the MIT-Japan International Studies Fund Grants, intended for advanced doctoral students at MIT working in close collaboration with faculty members on any international aspect of energy, environment, and international affairs.

Among the public events sponsored by CIS are the Starr Forum, the Emile Bustani Middle East Seminar, and the Security Studies Seminar Series. The Starr Forum mounts major public events for the MIT community and the broader public. The center’s website is also a source of information and analysis, news about CIS activities, and a fellowship database. Audits of Conventional Wisdom, the Foreign Policy Index, recent op-eds and articles by CIS scholars, videos of talks, and other resources are found online. Each year the center appoints as visiting fellows a few academics and government officials, both from the United States and abroad. Supported by
their universities, governments, or foundations, these fellows work on problems relevant to the center’s research and training interests. The Robert Wilhelm Visiting Fellow in International Studies is a distinguished visitor with extensive experience in government. The Elizabeth Neuffer Fellow is a woman journalist who reports on human rights and social justice.

For more information, contact executive director John Tirman, Room E40-447, 617-253-9861, tirman@mit.edu.

http://web.mit.edu/cis/

Center for Materials Science and Engineering

The Center for Materials Science and Engineering (CMSE), one of a nationwide network of Materials Research Science and Engineering Centers funded by the National Science Foundation, fosters collaborative interdisciplinary research and education in the fundamental science of materials and in the engineering of materials for long-range applications.

CMSE supports collaborations among MIT faculty and students from different disciplines, as well as between MIT researchers and researchers of other universities, industry, and government and nonprofit laboratories, and encourages collaborative research through interdisciplinary research groups (IRGs), shared experimental facilities (SEFs), infrastructure enhancement, and outreach programs.

The IRGs are composed of teams of MIT faculty, students, and postdoctoral associates from different disciplines who investigate fundamental scientific questions and engineering problems. More than 30 faculty members, representing ten different departments, are engaged in CMSE research in the following areas:

- Nanomaterials for electrochemical energy storage and conversion
- Mechanomorphic materials
- Multimaterial multifunctional nanostructured fibers
- High definition nanomaterials – new routes to 3D hierarchical nanostructured materials and devices
- Quantum optoelectronics and spintronics with topological insulator nanoscale devices

CMSE provides state-of-the-art instruments, maintained and supervised by trained staff, in its SEFs. This equipment is available to MIT investigators, including students, and researchers from other universities, industry, and research labs.

Facilities provide instrumentation to carry out electron microscopy; thermal, optical, and surface analysis; crystal growth; X-ray diffraction; neutron powder diffraction; X-ray scattering; and neutron scattering. They also provide technical training in the operation of these instruments to graduate and undergraduate students.

CMSE directly supports approximately 15 UROP students each year to participate in its research. Another 15 undergraduates from other universities spend the summer performing materials research on campus through the Summer Research Internship Program, jointly sponsored by CMSE and the Materials Processing Center.

The center does not offer a degree program or subjects for academic credit. Student registration is handled by academic departments.

Other education and outreach programs sponsored by CMSE include science and engineering summer day camp for seventh- and eighth-grade students from two Cambridge public schools and a summer research program for a small number of junior high and high school science teachers.

For further information, contact the center’s administrative office, Room 13-2106, 617-253-6850, fax 617-258-6478.

http://mit.edu/cmse/

Center for Real Estate

The Center for Real Estate provides an intellectual focus for research on issues affecting the real estate industry. Faculty associated with the center are drawn from the departments of Architecture, Urban Studies and Planning, Civil and Environmental Engineering, Economics, and the MIT Sloan School of Management.

The center’s research initiatives cover a range of disciplines and areas of application within real estate, and all offer synergy between the real world of practice and MIT’s faculty and research capabilities.

New Century Development is the center’s initiative aimed at understanding and improving the real estate development process in the 21st century. This initiative is interdisciplinary and international in scope, providing avenues to link across various departments at MIT, and between MIT and the community of professional practice engaged in building the developments of the future.

The Housing Affordability Initiative identifies ways in which MIT can make a unique, policy-relevant contribution to the challenges posed by the high cost of housing in eastern Massachusetts and elsewhere. Initial projects included the development of a multidimensional, micro-level housing affordability index that could help policy makers allocate funds and marshal political support for new housing development at the local level.

The Commercial Real Estate Data Laboratory provides a space (both virtual and real) for quantitative tools for measuring commercial real estate performance. The focus of research includes investment performance, management or operational performance, and environmental or social performance.

The center encourages interaction between members of the real estate industry and the academic community through seminars, colloquia, lectures, and a series of non-credit professional development courses offered through the Professional Development Institute.

The center is supported in part through corporate partnerships and individuals active in the real estate industry.

The center is also closely affiliated with the Master of Science in Real Estate Development (MSRED) program, an interdepartmental degree program that combines education in design, planning, construction, management, finance, and marketing. It prepares students to assume positions of responsibility in private real estate companies, financial institutions, government agencies, nonprofit development organizations, and consulting firms. The program requires 11 months of intensive study.

For further information about the center, contact Tony Ciochetti, chairman. For more information about the Master of Science in Real Estate Development (MSRED), contact David Geltner, director, MSRED Program, Center for Real Estate, Room 9-343.

http://web.mit.edu/cre/
Center for Transportation and Logistics
The MIT Center for Transportation & Logistics (MIT CTL), part of the Engineering Systems Division, is a world leader in supply chain management and transportation education and research. MIT CTL engages in three principal activities: research, outreach, and education.

Research. The center’s world-renowned research programs directly involve over 75 faculty and research staff from a wide range of academic disciplines, as well as researchers in various affiliate organizations around the world. MIT CTL has three main research programs: Supply Chain Management and Logistics, Transportation, and the impact of aging on mobility, health, and wellness.

Supply Chain Management and Logistics projects include Carbon Efficient Supply Chains; AgeLab; Demand Management; FreightLab; Scenario Planning; Strategy Alignment; Supply Chain 2020: The Future of the Supply Chain; Supply Chain Innovation in Emerging Markets; Supply Chain Security; the National Cooperative Highway Research Program’s Future Freight Flows; and Supply Chain Network Risk Management.

Transportation programs and projects include the New England University Transportation Center, the MIT Program in Intelligent Transportation Systems, and the National Center of Excellence for Aviation Operations Research.

The MIT AgeLab conducts research to improve quality of life for older adults and those who care for them, creating new ideas and translating technology into practical applications.

Outreach. MIT CTL partners with industry to turn the center’s innovative research into market-winning applications. MIT CTL currently has more than 45 corporate partners worldwide who participate in events, interact with researchers, and contribute to and help steer research projects.

Education. MIT CTL’s top-ranked academic programs include the MIT Supply Chain Management master’s program; the PhD program in Logistics and Supply Chain Management; and the MIT-Zaragoza International Logistics program, which offers graduate education in logistics and certifies in various logistics-related disciplines.

Through MIT CTL, MIT is the lead university in Federal Region I of the University Transportation Centers program administered by the US Department of Transportation, which provides graduate fellowships in transportation, research and teaching assistantships, and undergraduate research opportunities.

For further information on the Center for Transportation and Logistics and its programs, see Engineering Systems Division in Part 2.

http:// CTL. MIT.edu/

Computer Science and Artificial Intelligence Laboratory
The Computer Science and Artificial Intelligence Laboratory (CSAIL) pursues fundamental research across the entire breadth of computer science and artificial intelligence. CSAIL is committed to leading the field both in new theoretical approaches and in the creation of applications that have broad societal impact.

CSAIL’s current research activities span three principal areas:

Artificial Intelligence (AI). This area of research aims to understand and develop systems—living and artificial—capable of intelligent reasoning, perception, and behavior. Specific research includes core AI computational biology, computer graphics, computer vision, human language technology, machine learning, medical informatics, robotics, and the semantic web.

Systems. This area of research aims to discover common principles, models, metrics, and tools of computer systems, both hardware and software. Specific research includes compilers, computer architecture and chip design, operating systems, programming languages, and computer networks.

Theory. This area of research studies the mathematics of computation and its consequences. Specific research includes algorithms, complexity theory, computations geometry, cryptography, distrusted computing, information security, and quantum computing.

CSAIL encourages student participation in its research projects. Undergraduates may become involved through the Undergraduate Research Opportunities Program (UROP), and research assistantships are available to graduate students. CSAIL graduate students are typically enrolled in the departments of Electrical Engineering and Computer Science, Mathematics, Aeronautics and Astronautics, Brain and Cognitive Sciences, and Mechanical Engineering, and the MIT-Harvard Division of Health Sciences and Technology.

http://www.csail.mit.edu/

Deshpande Center for Technological Innovation
The Deshpande Center was established at the MIT School of Engineering to increase the impact of MIT technologies in the marketplace. Founded with an initial donation from Jaishee and Desh Deshpande, the Deshpande Center supports a wide range of emerging technologies including biotechnology, biomedical devices, information technology, new materials, tiny tech, and energy innovations.

Since 2002, the Deshpande Center has awarded over $11 million in grants to support more than 90 MIT faculty-led projects. The objective of the funding is to nurture ideas with market potential and reduce the uncertainty around them so that an external party would invest in the technology. In addition to the funding, the grants bring with them publicity, mentoring, and connections with the business community.

This funding enables MIT faculty and their students to pursue exciting new avenues of research on novel technologies. As a result, 26 projects have spun out of the center as independent startups, collectively raising more than $350M in outside financing from top-tier venture capital firms and other investors.

There are two ways for students to get involved in projects funded by the Deshpande Center.

1. i-Teams (Innovation Teams). i-Teams is a course that selects ambitious and highly qualified students interested in helping to bring leading-edge technologies from MIT’s world-renowned research laboratories to market. The students join teams devoted to evaluating commercial feasibility and creating go-to-market strategies for technologies within the Deshpande Center portfolio. The course is taught jointly through the Sloan School of Management and the School of Engineering. More information can be found at http://web.mit.edu/deshpandecenter/ iteams/index.html.

2. Deshpande Center Grant Program. The grant program identifies and supports MIT research that can address important market opportunities. To support this research, the center awards Ignition Grants and Innovation Grants (ranging from $50,000 to $250,000 per
project) to MIT faculty. Students may participate through a thesis or research assistantship in the laboratory of a faculty member. A portfolio of projects, including faculty contact information, can be found at http://web.mit.edu/deshpandecenter/portfolio.html.

The executive director of the Deshpande Center is Leon Sandler. The faculty director of the Deshpande Center is Professor Charles L. Cooney. Staff includes Michelle Grdina, program manager, and Erica Deary, administrative assistant. For more information, contact the Deshpande Center, Room 1-229, 617-253-0943, deshpandecenter@mit.edu.

http://web.mit.edu/deshpandecenter/

Division of Comparative Medicine
The Division of Comparative Medicine has three basic missions: education, research, and the provision of comprehensive animal husbandry, clinical, and diagnostic services for all research animals at MIT. The division serves as the centralized animal resource on campus and provides the necessary expertise for investigators conducting biomedical research using animal models.

Division staff members educate the MIT research community in the biology and use of research animals as models for biomedical research. The division provides online training materials for researchers working with animals as well as on-one-one training based on individual requirements. Division members teach graduate-level courses in the Department of Biological Engineering and provide mentorship for graduate students.

With an NIH-funded postdoctoral training program for veterinarians specializing in biomedical research, the major long-range goal of the research at the division is to develop animal models or in vitro systems that are pertinent to biomedical research. The division is internationally recognized for characterizing new Helicobacter species and studying the relationship of Helicobacter to diseases that are prevalent throughout the world.

http://web.mit.edu/comp-med/

Francis Bitter Magnet Laboratory
The Francis Bitter Magnet Laboratory conducts a program of research and development in science and engineering in areas involving magnetic fields, focused primarily on magnetic resonance.

High-field, high-resolution nuclear magnetic resonance (700, 750, and 900 MHz) and electron paramagnetic resonance (140 GHz) spectrometers are used for studies of molecules of biological interest and in areas of materials science. Spectrometers are made available on a routine basis in a collaborative and user mode to research groups from other MIT departments and institutions worldwide. In addition the laboratory operates pulsed magnets (giving fields up to 68 tesla).

Collaborative research programs are carried out with the departments of Physics, Electrical Engineering and Computer Science, Mechanical Engineering, Nuclear Science and Engineering, Materials Science and Engineering, Chemistry, and with the Plasma Fusion Center. These collaborative programs include participation by undergraduates and graduates working on theses. Undergraduate students in the Undergraduate Research Opportunities Program and others are also employed.

For information, contact the director, Professor Robert Griffin, Room NW14-3220, 617-253-5478.

http://web.mit.edu/fbml/cmr/

Haystack Observatory
MIT Haystack Observatory provides opportunities for undergraduate and graduate student research in radio astronomy, geodesy, and atmospheric sciences.

Haystack Observatory has long had a worldwide leadership position in the development and use of the Very Long Baseline (VLBI) technique, which uses a global array of radio telescopes to make high-resolution observations of galactic and extragalactic radio sources and to do precision geodetic studies of the Earth’s plate tectonics and motions in space. Using radio telescopes at Haystack and elsewhere around the world, the observatory supports strong programs in both science and technology using VLBI, including unique mm-wavelength observations of the black hole at the center of our galaxy on event-horizon scales.

High-power radars using 46-m and 67-m antennas are used, in conjunction with a variety of other techniques, to study the structure and dynamics of Earth’s upper atmosphere. Emphasis is given to the study of the effects of geomagnetic storms induced by solar disturbances on Earth’s ionosphere. Haystack researchers also study thermal effects in the upper atmosphere, including signatures associated with global climate change.

A strong instrumentation development program is conducted at Haystack Observatory, particularly in the areas of wideband signal processing and high-rate data acquisition. Current applications include the design of large radio arrays to improve the flexibility and sensitivity of radio observations, as well as ultra-broadband receiving systems for VLBI measurements.

Observatory researchers have led the development of an array spanning 80–300 MHz called the Murchison Widefield Array currently under construction in Western Australia. This innovative instrument offers rich opportunities for unique astrophysical and heliospheric science. Haystack scientists and engineers also are developing advanced low frequency digital radio array technologies for both ionospheric radar and astronomical applications.

Opportunities exist for students to get involved in all these projects and use the facility instrumentation for research investigations.

The Haystack Observatory is located in Westford, MA, about 35 miles northwest of Cambridge. For further information, contact Dr. Colin Lonsdale, MIT Haystack Observatory, Route 40, Westford, MA 01886, 781-981-5542, clonsdale@haystack.mit.edu.

http://www.haystack.mit.edu/

Institute for Medical Engineering and Science
The Institute for Medical Engineering and Science (IMES) is a new initiative launched in 2012 to create a focal point and effective platform for research and education in medical engineering and science at MIT. IMES is comprised of a community of scholars from across MIT and collaborating local-area hospitals who are focused on the intersections of engineering, basic sciences, and clinical research and practice. IMES is dedicated to addressing major health challenges using novel technologies and approaches.

Through its research and as a home to the Harvard-MIT Health Sciences and Technology graduate programs, as well as new educational programs, IMES aims to pioneer new research paradigms and graduate curricula to advance health and educate a generation of leaders working at the convergence of engineering, science, and clinical medicine. In partner-
ship with Harvard Medical School, IMES also plays a significant role in educating physician-scientists and physician-engineers who can integrate approaches from the physical sciences and engineering with the practice and science of medicine.

Opportunities for undergraduate research are available through the home department of faculty who are participating in IMES research, and through the Undergraduate Research Opportunities Program. For further information, contact the director, Professor Arup K. Chakraborty, Room E19-502C, 617-253-3890.

Institute for Soldier Nanotechnologies

Since 2002, MIT has hosted the Institute for Soldier Nanotechnologies (ISN), an interdisciplinary research center established under contract with the US Army. The ISN mission is to dramatically improve the survivability of the soldier by working at and extending the frontiers of nanotechnology through fundamental research. This mission includes not only decreasing the weight that soldiers carry, but also improving blast and ballistic protection, creating new methods of detecting and detoxifying chemical and biological analytes, and providing physiological monitoring and automated medical intervention.

The ultimate goal is to help the Army create a system of integrated nanotechnologies that combines high-tech capabilities with low weight and increased comfort. Imagine an ensemble that monitors health, eases injuries, communicates automatically, and maybe even lends increased abilities. It’s a long-range vision of how technology can make soldiers less vulnerable to enemy and environmental threats.

ISN research is mostly conducted by graduate students completing theses, by postdoctoral researchers, and by undergraduates working through the Undergraduate Research Opportunities Program (UROP). These researchers work in a 40,000-sq-ft facility on the MIT campus equipped with state-of-the-art laboratories designed and built for nanotech research.

Most theses are co-supervised by two or more faculty members representing different areas of technical expertise. Approximately 50 MIT faculty members participate in ISN research annually. They hail from more than a dozen academic departments and centers, making ISN one of the most scientifically diverse research organizations at MIT.

In addition, many projects involve the participation of visiting experts from industry and from Army laboratories and centers of excellence. These experts often bring practical perspectives that contribute significantly to the rich learning environment at ISN. Industry partners help to turn laboratory innovations into real products and scale them up for affordable manufacture. Army partners collaborate on basic and applied research, provide guidance on the soldier relevancy of ISN projects, and participate in transitioning.

Students seeking to perform thesis or UROP research in ISN should contact affiliated faculty within their own department. Information may also be obtained from ISN at 617-324-4700 or isn@mit.edu.

http://web.mit.edu/isn/

Institute for Work and Employment Research

The Institute for Work and Employment Research (IWER) is an MIT-wide multidisciplinary research and educational unit located within MIT Sloan School of Management and the Engineering Systems Division. Since its establishment in 1937 (as the MIT Industrial Relations Section), IWER has conducted research devoted to the full range of issues related to work, labor and employment relations, human resource management, labor market issues, and related public policies. Participating faculty are drawn from the Sloan School and the departments of Economics, Political Science, Anthropology, and Urban Studies and Planning.

IWER faculty and graduate students conduct research on the broad range of issues related to the role of work and employment in the contemporary economy and society, including labor-management relations, human resource strategies and practices in both mature and new entrepreneurial organizations, work and family relationships, human capital and corporate governance, labor market theory and policy analysis, the changing nature of work and occupations, negotiations theory and practice, dispute resolution, and labor and employment policy. Together with colleagues at Stanford and several other universities, IWER faculty recently launched a major study of employment standards in global supply chains.

The institute administers a PhD program and fellowships primarily for students enrolled in the MIT Sloan PhD program, but students from other departments at MIT are encouraged to become members of IWER. IWER participate in weekly seminars, and work closely with faculty members. The seminar series on Changes and Challenges in the World of Work is held every Tuesday. Together faculty and students at MIT and in the Boston area to discuss work in progress and serving as a major focal point for interest in this field.

IWER’s codirectors are Thomas A. Kochan and Paul Osterman. For more information, contact Katherine Bertman, Room E62-331, 617-253-8515, fax 617-253-2660, iwer@mit.edu.

http://mitsloan.mit.edu/iwer/

Joint Program on the Science and Policy of Global Change

The Joint Program on the Science and Policy of Global Change integrates natural and social science to produce analyses relevant to climate and energy policy debates. By bringing together both science and policy, the Joint Program provides a truly independent integrative assessment of the impacts of climate change and the expected values of responsive action. The research conducted at the Joint Program is valuable to government agencies, who aim to formulate efficient and effective policies; to industries, who aim to create risk management strategies within national, regional, and global market realities; and to other decision-makers, who value a systemic view of the broad interactions inherent in global change. The effort involves an interactive group of faculty, staff, and student researchers.

The Joint Program combines the capabilities of two complementary interdisciplinary research centers: the Center for Global Change Science (CGCS) and the Center for Energy and Environmental Policy Research (CEEPR). Resources of the parent centers are strengthened by links to the Marine Biological Laboratory’s Ecosystems Center in Woods Hole, MA; the MIT Climate Modeling Initiative; and other MIT environmental programs. Cooperative efforts engage the Joint Program with leading research institutions and nonprofit organizations worldwide. Financial support is provided by an international group of sponsors from government organizations, foundations, and industry.

The Joint Program’s primary research tool is the MIT Integrated Global System Model (IGSM) framework, which is a facility for simulating global
change and for assessing the effects of policy proposals. IGSM is a comprehensive modeling framework for analyzing potential anthropogenic global climate change and its social and environmental consequences. It combines models of the Earth system and models of human activities and the economy to address global change issues with a holistic, systemic approach. The IGSM can be used to evaluate probabilities, uncertainties, risk, and costs and benefits—information crucial to policy decision making.

Joint Program members communicate research results and interpret policy relevance of analytical work through many professional activities, including publications, workshops, corporate and public briefings, and media interviews. Special briefings from program members have been requested by the US Congress and federal and state agencies, by governmental ministries and international organizations, and by independent research panels. Joint Program research is communicated directly to sponsors through the MIT Global Change Forum. This semiannual event brings together representatives of industry, government, international entities, and research groups for analysis and discussion of science and policy aspects of global change, and for independent assessment of studies and policy proposals.

Ronald Prinn, director of the Center for Global Change Science and professor within the Department of Earth, Atmospheric, and Planetary Sciences and John Reilly, senior lecturer in the Sloan School of Management and the Center for Energy and Environmental Policy Research, codirect the program. For further information, contact the Joint Program office, Room E59-411, 617-253-7492, fax 617-253-9845, globalchange@mit.edu.

**Knight Science Journalism Program**

The Knight Science Journalism Program offers fellowships to mid-career journalists who cover science, technology, medicine, or the environment for the general public. The program offers fellowships to reporters, writers, editors, producers, illustrators, and photographers.

Journalists who are selected spend one academic year on campus, taking courses at MIT and Harvard, participating in twice-a-week seminars with top researchers, visiting laboratories, going on field trips, and pursuing independent projects.

Science journalists face some of the most difficult challenges of reporting. They must convey complex, technical subjects in direct, simple terms to readers and viewers who demand—and have a right to—accurate, fair, and clear information about scientific developments that affect not only their views of the world, but their lives and livelihoods.

Reporting both the news and its implications is further complicated by the naturally advancing complexity of science.

Knight fellowships are designed to help journalists face these challenges by widening their knowledge of science and technology and deepening their understanding of how these fields interact with society. Also, they provide an opportunity for journalists to re-examine old ways of practicing their craft and to develop new ways.

The John S. and James L. Knight Foundation is the principal sponsor of the fellowships, the only nine-month, mid-career program reserved for science journalists. The fellowships are part of MIT’s Program in Science, Technology, and Society. For further information, contact Philip Hilts, director, Room E59-623, 617-253-3442, philh@mit.edu.

**Koch Institute for Integrative Cancer Research**

The David H. Koch Institute for Integrative Cancer Research at MIT is one of the two National Cancer Institute-designated centers in the Greater Boston area. The Koch Institute’s faculty participate in highly interdisciplinary research projects spanning across many areas of fundamental cancer research, including molecular, cellular, and developmental biology; immunology; nanotechnology; and diverse applications of biomedical engineering. The new David H. Koch building opened in 2010 and has brought together scientists and engineers under one roof to develop new ways to detect, diagnose, treat, and manage cancer.

The Koch Institute draws its faculty from both the School of Science and the School of Engineering. Graduate students typically enroll in the departmental program, but students in any MIT department may ask to do doctoral thesis research under the supervision of the Koch Institute’s faculty. If accepted, they may be eligible for support as research assistants.

Opportunities for undergraduate research are available through the Undergraduate Research Opportunities Program. Occasional seminars on cancer research, offered as public colloquia, are also available.

For further information, contact the director, Professor Tyler Jacks, Room 76-158, 617-253-6403.

**Laboratory for Financial Engineering**

The techniques of financial engineering have become indispensable to a wide spectrum of business activities, including investment banking, commercial banking, corporate finance, capital budgeting, portfolio management, risk management, and financial consulting and planning.

The principal focus of the Laboratory for Financial Engineering (LFE) is the quantitative analysis of financial markets using mathematical, statistical, and computational models. The goal of LFE is not only to spur advances in financial engineering, but also to develop better ways to teach students and executives how to apply financial technology in corporate settings.

Students are encouraged to participate in current research projects, which include the empirical validation and implementation of financial asset pricing models, the pricing and hedging of options and other derivative securities, risk management and control, trading technology and market microstructure, nonlinear models of financial time series, neural-network and other nonparametric estimation techniques, high-performance computing, and public policy implications of financial technology. LFE is a research lab for students currently enrolled at MIT and does not offer any degree programs.

Professor Andrew W. Lo is the director of the laboratory. For further information, contact Jayna Cummings, Room E62-611, 617-258-5727, jcummin@mit.edu.
Laboratory for Information and Decision Systems

The Laboratory for Information and Decision Systems (LIDS) is an interdisciplinary laboratory for research and education in systems, networks, and control. LIDS is staffed by faculty, research scientists, and graduate students from the departments of Electrical Engineering and Computer Science, Aeronautics and Astronautics, and Mechanical Engineering, as well as the Sloan School of Management. LIDS research falls into four main areas.

Research in Networks includes research on communication networks and information theory. The work extends to applications in satellite, wireless and optical communications, and data networks. In addition, major new directions include the analysis of social networks and of interactions among networked systems and/or agents, with applications ranging from analysis of data from large-scale social networks to the dynamics and risk in large interconnected financial, transportation, and power systems.

The Statistical Inference and Machine Learning group analyzes complex systems, phenomena, and data subject to uncertainty and statistical variability. Research ranges from basic theory, methodologies, and algorithms to challenging applications in a broad array of fields. Applications include multi-sensor data assimilation for earth sciences, biomedical image analysis, object recognition and computer vision, and discovery of complex interactions and behaviors in video and other data sources.

Work in Optimization looks at analytical and computational methods for solving optimization problems arising in engineering and operations research. It has applications in communication networks, control theory, power systems, machine learning, and computer-aided manufacturing. In addition to linear, nonlinear, dynamic, convex, and network programming, the solution of large-scale problems exploiting algebraic structure and simulation-based methods is examined.

The Control and System Theory group deals with all aspects of systems analysis, including learning and system identification, controller design and optimization, and analysis of distributed systems involving the interaction of information and control. Theoretical research quantifies fundamental capabilities of learning and feedback control in the presence of uncertainty. Applications include control architectures for unmanned vehicles and controllers for semiconductor manufacturing.

For further information, contact LIDS director, Professor Alan S. Willsky, Room 32-D608, 617-253-2142.

Laboratory for Manufacturing and Productivity

The Laboratory for Manufacturing and Productivity (LMP) is an interdepartmental laboratory for research and education in manufacturing and productivity at MIT. The laboratory seeks to establish a rational foundation for manufacturing based on a systematic understanding of the complex interactions among the many areas of manufacturing. The three major objectives are: (1) the development of the fundamental principles of manufacturing processes, equipment, and systems; (2) the application of those principles to the manufacturing; and (3) the education of engineering leaders.

The laboratory draws upon faculty and staff mainly from the Department of Mechanical Engineering, but participates in wide-ranging programs that involve many other departments and programs at MIT. Since its establishment in 1977, LMP’s research program has contributed to innovation in manufacturing processes and equipment, and has nurtured a greater understanding of planning, design, and production operations.

LMP’s three research focus areas are micro- and nano-scale manufacturing processes and equipment, manufacturing systems and information technology, and sustainability, including photovoltaics and environmentally benign manufacturing.

Opportunities for undergraduate and graduate students are available for thesis research and Undergraduate Research Opportunities Program projects, as are a limited number of postdoctoral research positions.

For additional information, contact the director, Professor Jung-Hoon Chun, Room 35-233, 617-253-1759. http://web.mit.edu/lmp/

Laboratory for Nuclear Science

Research in the Laboratory for Nuclear Science (LNS) seeks to understand the structures and interactions of the fundamental constituents of matter. LNS supports research interests of faculty in the Department of Physics by supporting and administering facilities for studies of nuclear and particle physics, including the Center for Theoretical Physics, the Bates Linear Accelerator Center, the Bates High Performance Research Computing Facility, and the MIT Central Machine Shop. Students participate in the entire range of research programs in fulfilling their graduate and undergraduate degree requirements or as participants in the Undergraduate Research Opportunities Program.

Nuclear physics experiments are performed with electrons at the Thomas Jefferson National Accelerator Facility, with polarized protons at Brookhaven National Laboratory, with neutrons at the Los Alamos Neutron Science Center, and with electrons and positrons at the DESY Laboratory in Germany. The high-energy particle physics program involves experiments with both high-energy protons and heavy ions at the Large Hadron Collider at CERN in Switzerland, the search for antimatter and dark matter in space with the Alpha Magnetic Spectrometer on the International Space Station, and additional dark matter experiments at WIPP in New Mexico and SNOLab in Canada. Properties of neutrinos are being explored through experiments at Fermil National Accelerator Laboratory, Karlsruhe, Germany, and Chooz, France. A theoretical program investigates the properties of high-energy plasmas.

For further information, contact the director, Professor R. Milner, Room 26-505, 617-253-2395.

The Center for Theoretical Physics is engaged in a broad range of fundamental research activities in theoretical nuclear and particle physics, including study of the fundamental constituents of matter and the theory that governs them, the structure and interactions of nuclei and hadrons, electroweak physics, lattice hadron physics, field theory, string theory and quantum gravity, many-body physics, mathematical physics, cosmology, and quantum computation.

For further information, contact the director, Professor E. Farhi, Room 6-300, 617-253-4571.

The William H. Bates Linear Accelerator Center is operated by LNS as a research and engineering center with particular emphasis on accelerator science and technology. Current efforts include the design, construction, and testing of new detector systems; the design of the high-luminosity electron-ion collider eRHIC; development of a proton synchrotron for...
cancer therapy; and development of new accelerator-based techniques for screening cargo for dangerous materials.

For further information, contact the director, Professor R. Redwine, Room 26-453, 617-253-3600.

http://www-lns.mit.edu/

Lean Advancement Initiative

The Lean Advancement Initiative (LAI) is a research consortium that offers the newest thinking, products, and tools to enable and accelerate the transformation of complex enterprises. LAI and its members engage collaboratively to develop and institutionalize principles, processes, behaviors, and tools for enterprise excellence. Founded in 1993, LAI resides within the Sociotechnical Systems Research Center of the Engineering Systems Division (ESD) in the School of Engineering. Faculty from the Department of Aeronautics and Astronautics and the MIT Sloan School of Management participate in LAI research. More than 225 graduate students from Aeronautics and Astronautics, ESD, Mechanical Engineering, Sloan School of Management, System Design and Management, and other programs have completed master’s and doctoral theses within LAI.

LAI conducts its research in close collaboration with its members and has developed an array of unique products and tools to help members assess, analyze, transform, and architect their enterprises. These products include the Lean Enterprise Self-Assessment Tool, Enterprise Transformation Roadmap, Enterprise Strategic Analysis for Transformation, Product Development Value Stream Mapping Manual, and Systems Engineering Leading Indicators Guide Version 2.0.

LAI’s Educational Network (EdNet) is an international group of 65 educational institutions that develop and deploy curricula based on LAI’s latest research, practical knowledge, and member best practices. These curricula include the LAI Lean Academy®, LAI Lean Engineering Seminar™, LAI Lean Healthcare Academy™, Lean Enterprise Value Short Course, and customized courses.

LAI has captured major findings in its 2011 book, Beyond the Lean Revolution: Achieving Successful and Sustainable Enterprise Transformation. Additional information is available on the LAI website. http://lean.mit.edu/

Legatum Center for Development and Entrepreneurship

The Legatum Center for Development and Entrepreneurship at MIT was founded on the belief that economic progress and good governance in low-income countries emerge from entrepreneurship and innovations that empower ordinary citizens. The center administers a highly competitive fellowship program for MIT graduate students who intend to launch enterprises in developing countries. The center also convenes an annual conference, offers educational programs, and awards seed grants to support student teams working on innovative projects in emerging economies.

Legatum Fellows benefit from business plan coaching, tuition assistance, networking events, specialized programs and coursework, and access to the expertise and experience of Legatum Mentors.

Seed Grant recipients benefit from awards that fund market research, prototype development, pilot testing, proofs of concept, and international travel.

The Legatum Center is directed by Professor Iqbal Quadir. For more information, contact legatum@mit.edu.

http://legatum.mit.edu/

Lincoln Laboratory

MIT’s Lincoln Laboratory, in Lexington, MA, is operated as a federally funded center for research and development of advanced technologies in support of national defense.

Lincoln Laboratory’s activities focus on design and development of complex systems, usually incorporating new technologies, devices, and components. The Laboratory’s mission areas are communication systems; space control; air and missile defense technology; intelligence/surveillance/reconnaissance systems and technology; advanced electronics technology; tactical systems; homeland protection; cyber security; and air traffic control.

Opportunities for research are available to MIT faculty members and qualified students. Inquiries may be directed to Bernadette Johnson, chief technology officer, LIN S3-112, MIT Lincoln Laboratory, 244 Wood Street, Lexington, MA 02420, or via email to bernadette@ll.mit.edu. The Laboratory also offers student employment opportunities, which may be viewed on its website.

http://www.ll.mit.edu/

Martin Trust Center for MIT Entrepreneurship

The Martin Trust Center for MIT Entrepreneurship educates and nurtures students from across the Institute who are interested in learning the skills to design, launch, and grow innovation-based ventures. The center supports a variety of teaching activities in all aspects of entrepreneurship, which provide a combination of project-based and theory-based learning. Project-based classes include New Enterprises, Innovation Teams, and Entrepreneurship Lab; theory-based classes include Entrepreneurial Finance, Strategic Management of Innovation and Entrepreneurship, and Dilemmas in Founding New Ventures. Over 30 subjects are offered, involving more than 25 faculty members.

All entrepreneurship subjects, described in the online MIT Subject Listing & Schedule (http://student.mit.edu/catalog/index.cgi), are open to graduate students from all MIT departments, and support the strong community of MIT entrepreneurship and innovation. Subjects frequently feature invited speakers who have significant real-world experience to share. The classes provide students with insights based on leading-edge research on entrepreneurship and related topics, such as the role of science and innovation in economic growth, and the characteristics of effective entrepreneurial firms.

The Martin Trust Center supports and cooperates closely with a wide array of related organizations at MIT, including the MIT Technology Licensing Office, the Deshpande Center for Technological Innovation, the Venture Mentoring Service, the Legatum Center for Development and Entrepreneurship, and the Lemelson-MIT Program. It also supports a range of student activities including the MIT $100K Entrepreneurship Competition, the MIT Clean Energy Prize, the MIT Entrepreneurship Review, the MIT Venture Capital and Private Equity Club, the MIT Healthcare Club, the MIT Sloan Sales Club, MIT Sloan Entrepreneurs for International Development, and the MIT Energy Club.
Bill Aulet is the managing director, Professor Fiona Murray is the faculty director, and Professor Edward B. Roberts is the founder and chair. The Martin Trust Center is also supported each semester by a group of entrepreneurs-in-residence who have founded high-impact innovation-based companies and organizations from scratch and provide advice to students with similar goals.

For more information, contact the Martin Trust Center, Room E40-160, 617-253-8653, fax 617-253-8633, trustcenter@mit.edu.

http://entrepreneurship.mit.edu/

Materials Processing Center
The Materials Processing Center (MPC), an interdisciplinary center within the School of Engineering, provides an environment where industry, government, and academia can collaborate to identify and address multidisciplinary issues in materials processing and manufacturing.

MPC focuses on strengthening and enhancing its intellectual community, increasing industrial outreach, and creating partnerships with industry to focus on research and education. These partnerships address current issues in all materials sectors, but especially in energy, information technology, transportation, primary materials, construction, biotechnology, and technologies for sustainability.

MPC cosponsors the MPC/CMSE Summer Scholar Program, inviting outstanding undergraduate students nationwide to participate in ongoing MIT materials research. The program has brought hundreds of college juniors and seniors to conduct graduate-level materials research.

With its Industry Collegium, MPC acts as the primary window to industry for MIT’s broad materials research community. Collegium member companies benefit from this liaison with MIT in many ways. Publications promoting materials processing activities at MIT are distributed widely to industrial and government contacts. MPC sponsors a major workshop involving both students and faculty during its Materials Day celebration each fall. In cooperation with MIT’s Industrial Liaison Program, MPC and the Microphotonics Center also provide a forum for industrial representatives to discuss their needs and problems one-on-one with MIT faculty and researchers. MPC also encourages exchanges between academia and industry, through visiting scientists, adjunct faculty appointments, and industrial internship educational opportunities.

The Microphotonics Center is a center within MPC that builds interdisciplinary teams focused on advancing basic materials science and emerging technology in integrated photonic systems. It serves as a research community in which industry, government, and academia collaborate to create new materials, structures, and architectures for the emerging “microphotonics platform”—the menu of on-chip and circuit-board level devices and components that will comprise future optoelectronics for computing, imaging, and learning. The Microphotonics Industry Consortium creates a proactive forum where scientists, engineers, and strategists from industry and MIT can work as partners in exploring and pursuing innovative microphotonics research and development.

For more information, contact Mark Beals, associate director, Room 12-007, 617-253-2129, mbeals@mit.edu.

http://mpc-web.mit.edu/

McGovern Institute for Brain Research
The McGovern Institute for Brain Research at MIT is a research and teaching institute committed to meeting two great challenges of modern science: understanding how the brain works and discovering new ways to prevent or treat brain disorders.

Research at the McGovern Institute is organized around three broad themes: perception, cognition, and action. Together these themes correspond to the flow of information through the brain—from the sensory systems that receive and interpret input, to the higher regions that underlie cognition, and finally to the motor systems that control our actions. Our research employs the full range of modern neuroscience techniques, from molecular genetics to functional neuroimaging and computational modeling. A deeper knowledge of the human brain will have profound implications, both for our understanding of our own minds and for the treatment of the many brain diseases that lead to human suffering.

The institute currently has 15 principal investigators and continues to grow. All McGovern Institute faculty members hold dual appointments in departments at MIT. Each of our faculty members leads a research team, and the institute as a whole comprises a community of more than 200 researchers and support staff.

The main focus for undergraduate neuroscience education at MIT is Course 9, leading to the Bachelor of Science in Brain and Cognitive Sciences. There are many opportunities for undergraduates to work in McGovern labs, for example through the MIT Undergraduate Research Opportunities Program.

The McGovern Institute does not operate its own graduate program. Instead, graduate students must enroll in one of the departmental or interdepartmental graduate programs at MIT. The majority of graduate students within the McGovern Institute are enrolled in the Brain and Cognitive Sciences graduate program.

For more information about undergraduate and graduate opportunities at the McGovern Institute, visit http://mcgovern.mit.edu/work-here/types-of-positions/. To learn more about the institute, contact the director, Dr. Robert Desimone, Room 46-3160, 617-324-0639.

http://mcgovern.mit.edu/

Media Lab
The Media Lab is about people, computation, and quality of life in a digital age. True to the vision of its founders, the lab continues to focus on the study, invention, and creative use of “enabling technologies for learning and expression by people and machines.” Its work is rooted in modern communication, computer science, and natural and human sciences, and its academic program is intimately linked with research. Media Arts and Sciences, the academic program linked to the lab, can be thought of as exploring the technical, cognitive, and aesthetic bases of satisfying human interaction as mediated by technology.

Computers and computation are the most prominent common denominators of this multidisciplinary merger of previously separate domains. The birthplace of multimedia computing, the lab is engaged in research that includes computing culture, electronic publishing, software agents, multimodal interfaces, structured audio, digital and networked video, constructionist learning, conversational computing, pervasive computing, tangible media, personalized media, gender- and age-based computing, metadata representations, common-sense computing, personal fabrication, affective computing, and silicon biology.
The activities of the lab revolve around a core of learning, perceiving, and expressing. Current foci include both the means of expression (the underlying science and technology needed to merge the bits of the digital world with the atoms of the physical world) and its meaningful application to the arts (performance and the study of the principles of analysis and synthesis in computational media). Furthermore, the lab aims to address major social challenges (improving education, enhancing health care, and supporting community development) through the innovative design and use of new technologies.

Many of the lab’s research activities are conducted within the context of corporate-funded programs. The focus on corporate support reflects the lab’s commitment to collaborative research: a dialogue with industry (and other non-academic) partners provides a forum for ongoing professional critique; technology transfer moves research results out of the lab and into worldwide use. Drawing upon a broad, international base, industries represented range from electronics to entertainment, furniture to finance, and toys to telecommunications.

The graduate academic Program in Media Arts and Sciences is based within the School of Architecture and Planning. Students work closely with faculty members as well as with lab sponsors.

For further information, contact Joichi Ito, director, Room E14-245, 617-324-3818.

http://www.media.mit.edu/

Microsystems Technology Laboratories
The Microsystems Technology Laboratories (MTL) provide modern fabrication facilities to enable research and education in nano- and micro-technologies.

The MTL facilities consist of fully equipped cleanroom laboratories and associated design, simulation, testing, and characterization infrastructure, as well as an extensive computational network, supporting wide array of design and layout tools.

MTL’s nano-/micro-fabrication, testing, and computational facilities are available to the entire MIT community as well as researchers from other universities or government laboratories. MTL is also available for limited industrial participation.

Research at MTL is conducted in four separate spaces: the Integrated Circuits Laboratory (ICL), the Technology Research Laboratory (TRL), the Exploratory Materials Laboratory (EML), and the Electron Beam Lithography Laboratory (EBL). ICL has been designed, equipped, and staffed to serve as a highly advanced silicon integrated circuit, device, structures, and process research facility. TRL supports the development of novel process technologies by providing facilities for the fabrication of novel micro- and nano-structures. EML is a highly flexible lab with all basic fabrication capabilities and almost no restriction on materials. The EBL provides advanced lithographic services using a high-resolution fast through-put Elionix F-125 e-beam writer; it is jointly managed by MTL and the Research Laboratory of Electronics.

More than 145 faculty and senior research staff, 650 graduate students, 150 undergraduates, and 20 postdoctoral associates are involved in ongoing activities at MTL. Approximately 55 PhD and 45 SM and MEng degrees whose primary area of research is strongly coupled to MTL facilities are awarded each academic year.

For information regarding MTL’s technical operations and capabilities, contact Dr. Vicky Diadiuk, associate director for operations, 617-253-0731, diadiuk@mit.edu. For information regarding MTL programs and other general information, contact Samuel Crooks, associate director for administration, 617-253-3978, crooks@mit.edu.

http://mtlweb.mit.edu/

Middle East Program at MIT
The Middle East Program at MIT, an interdisciplinary course of study taken in conjunction with the graduate program in a student’s chosen department, focuses on technology, development, and public policy. The program enables students with an interest in the Middle East (including North Africa and South Asia) to develop an expertise in the area within the context of a coherent program of study. It equips students with an understanding of the processes of socioeconomic change, technological development, political change, environmental management, knowledge networking, institutional development, sustainability strategies, and international business and investment patterns in the region.

The program draws on MIT’s unique strengths in science and technology to offer a course of study distinct from a conventional “area studies” approach to the Middle East. The emphasis at present is on challenges of design and development in the reconstruction of the region following violent conflicts, as well as on innovations and applications of advances in information technology and knowledge e-networking to support development objectives.

The program draws on faculty from the departments of Political Science, Civil and Environmental Engineering, and Urban Studies and Planning; the History Section; the Sloan School of Management; the Program in Science, Technology and Society; and the Aga Khan Program in Islamic Architecture.

For further information, contact Professor Nazli Choucri, Department of Political Science, Room E53-493, 617-253-6198, nchoucri@mit.edu.

MIT Catalyst Clinical Research Center
The MIT Catalyst Clinical Research Center is an NIH-funded research facility on campus that provides an infrastructure for interested scientists to perform biomedical research involving human subjects.

Its mission is to support the translation of basic science discoveries into clinical (human) research that may improve the lives of patients and their families. Its existence allows students at all levels to gain experience with human subjects and human disease. Research projects in progress are in the areas of psychiatry, neurology, endocrinology, human nutrition and metabolism, and biomechanical engineering. Disorders under study include autism, dyslexia, ADHD, depression, bipolar disorder, anxiety, social anxiety disorder, and schizophrenia. Most projects involve collaboration between physicians and clinical research scientists, and often involve local hospitals.

The facilities of the center are open to all departments in the Institute, and its principal investigators are faculty members and research scientists from many different departments. The center has state-of-the-art instruments and supports processing of samples. The specialty of clinical research nursing, whose focus is the care of the research participant, provides expertise in the operationalization of research protocols. This practice may include study design consultation, study implementation, data acquisition and processing, safety monitoring, data management, and subject education.
Research opportunities are available for undergraduate and graduate students contemplating careers in the medical sciences. The Undergraduate Research Opportunities Program (UROP) allows undergraduate students the opportunity to participate in the research process at the Clinical Research Center—either for credit, pay, or on a volunteer basis.

For further information, contact the program codirectors, Drs. John Gabrieli and Ravi Thadhani, or the administrative director, Lee Mavros Rushton, Room E25-201B, 617-324-5493.

http://crc.mit.edu/

MIT Center for Art, Science, and Technology

The Center for Art, Science, and Technology (MIT CAST) facilitates and creates opportunities for exchange and collaboration among artists, engineers, and scientists. A joint initiative of the Office of the Provost, the School of Architecture and Planning, and the School of Humanities, Arts, and Social Sciences, the center is committed to fostering a culture where the arts, science and technology thrive as interrelated, mutually informing modes of exploration, knowledge and discovery.

CAST's activities include:

- Soliciting and supporting cross-disciplinary curricular initiatives that integrate the arts into the core curriculum and create new artistic work or materials, media, and technologies for artistic expression
- Spearheading a visiting artists program that emphasizes creative process, extensive interaction with MIT faculty, students, and researchers, and cross-fertilization among disciplines
- Assisting in the presentation and curation of performing and visual arts or design relevant to the research of engineers, scientists, and the MIT community as a whole
- Disseminating the creative and intellectual production supported by the center to the public through performances, exhibitions, installations, and a biennial symposium
- Supporting graduate students and postdoctoral researchers whose work advances the mission of the center

The faculty director of CAST is Professor Evan Ziporyn, 10-283, zipo@mit.edu. The executive director is Leila Kinney, 10-183, lwkinney@mit.edu.

http://arts.mit.edu/cast/

MIT Center for Digital Business

The MIT Center for Digital Business was created in partnership with industry to better understand the opportunities for radical change created by the internet and related technologies. Its aim is to provide thought leadership and implement tools and frameworks for analyzing internet-enabled technology, management, and business strategy through one-to-one relationships with corporate partners. Based at the MIT Sloan School of Management, the center also draws on other MIT resources, including the World Wide Web Consortium, the Center for Information Systems Research, the Center for Collective Intelligence, the Computer Science and Artificial Intelligence Laboratory, and the Media Lab. To date the center has funded more than 70 research projects with more than $30 million in corporate support.

The center's research is organized into four special interest groups: productivity, marketing, services, and the cloud. Sponsors of the center participate closely in a focused research project as well as the annual conference, topical research workshops, and biweekly webinar lunches.

For more information, contact David Verrill, Room NE25-769, 617-452-3216, fax 617-452-3231, dverrill@mit.edu.

http://digital.mit.edu/

MIT Energy Initiative

The MIT Energy Initiative (MITEI) helps transform the global energy system to meet the needs of the future and helps build a bridge to that future by improving today’s energy systems. The four components of the MITEI program are energy research, education, campus energy management, and outreach activities. For information, visit http://web.mit.edu/mitei/.

Research

MITEI pairs MIT’s research teams with industry members responsible for moving the products of this collaboration into the energy marketplace. The resulting enabling energy technologies have the potential to address multiple energy challenges; the delivery of energy products and services at scale; and the provision of energy products and services in highly complex policy, legal, and regulatory environments.

Education

MITEI’s education program develops cross-disciplinary learning opportunities and assists students with energy opportunities beyond the classroom, supporting students through a variety of programs:

- An Institute-wide undergraduate Minor in Energy Studies launched in fall 2009. Overseen by a faculty committee with representatives from all five Schools, the minor complements the deep expertise obtained in a student’s major with a broad understanding of the interlinked realms of science, technology, and social sciences as they relate to energy and associated environmental challenges.
- MIT Energy Fellowships
- Undergraduate Research Opportunities Program placements
- Energy Classes website
- Support for student groups focusing on energy and the environment

The MITEI Education Office supports the Energy Education Task Force with energy curriculum development and establishing and communicating a model for interdisciplinary energy education at MIT.

For more information, contact Dr. Amanda C. Graham, director, agraham@mit.edu, or visit http://web.mit.edu/mitei/education/.

Campus Energy Activities

MITEI’s campus energy program has continued to build on earlier progress making the campus a model living laboratory while seeking reductions in campus-wide energy use. Activities include energy system upgrades, student-run projects to reduce energy use and emissions, on-campus testing of specific innovative measures, a major study to look at all energy options, and web postings of guidelines for use by other universities and institutions. A recent major accomplishment was the establishment of MIT Efficiency Forward: a three-year, $13 million collaborative energy conservation and efficiency program with utility company NSTAR.
INTERDISCIPLINARY RESEARCH AND STUDY

Drawing on faculty, staff, and students, the Campus Energy Task Force engages MIT energy experts, implements the newest approaches and technologies developed in their research, and builds on the expertise of MIT’s administrative and operational resources to make MIT’s campus a model of sustainability. Energy conservation programs, sustainable building design features, student competitions, increased community awareness and engagement, and unique campus energy learning opportunities are results of these collaborations.

For more information, visit the campus energy program website at http://mit.edu/mitei/campus/. For information on the campus energy program and its activities, contact Steven Lanou, deputy director for environmental sustainability, Environment, Health and Safety Headquarters Office, slanou@mit.edu.

Outreach
MITEI supports a monthly lecture series in addition to several colloquia and seminars each year. The lecture series is designed to share current research from MIT and elsewhere, and is attended by students, faculty, and staff involved in energy research as well as by the local community. Colloquia bring together much larger and diverse MIT constituencies and feature more general-interest energy discussions following talks by prominent policy makers.

In addition, MITEI implemented the MITEI Associate Member Program Symposium Series focusing on bringing together groups of energy experts for formal discussion and analysis of timely and critical energy issues. Four symposiums have been held since the program was established in 2010.

The outreach group also publishes Energy Futures, a semi-annual magazine of energy research, education, and campus innovation at MIT.

Interdisciplinary Studies
Outreach activities include reports based on multi-stakeholder symposia and subsequent research and a program of interdisciplinary studies on the future of specific energy technologies, including nuclear power, coal, natural gas, solar energy, nuclear fuel cells, and the electric grid. In March 2012, the latest in the series of symposium reports, Managing Large-Scale Penetration of Intermittent Renewables, was released. The Future of...

studies, aimed at informing leaders in government and industry, examine conditions that enable technology and policy choices in critical areas. The most recent of these studies addressed The Future of Natural Gas and The Future of the Electric Grid.

http://web.mit.edu/mitei/

MIT Kavli Institute for Astrophysics and Space Research
The MIT Kavli Institute for Astrophysics and Space Research (MKI) offers students, faculty, and professional research staff opportunities to participate in a broadly based program of space-related research. For example, research programs are carried out in X-ray, radio, optical, and planetary astronomy, space plasma and gravitational physics, and space engineering. Areas of research include cosmology, black holes and neutron stars, and extrasolar planets, among other topics.

Studies often involve experiments carried by the space shuttle, orbiting satellites, or deep space probes. The experimental programs are complemented by ground-based research in similar fields and by laboratory development of suitable instrumentation for the space-based and ground-based experiments. An active program of theoretical studies in astrophysics and space physics is also supported.

MKI is the focus for MIT’s participation in the Magellan Observatory Consortium in Chile, the Laser Interferometer Gravity Wave Observatory, the Chandra X-ray Observatory Science Center, and, in collaboration with Haystack Observatory, the Murchison Widefield Array radio telescope in Western Australia. Extensive data handling and computational facilities are available for the analysis and reduction of scientific data. An experienced, well-equipped group of engineers and technicians provides design, construction, and testing of instrumentation in support of the ground-based and flight programs.

The variety of scientific and technical problems that arise in these investigations affords numerous opportunities for graduate thesis research. In addition, there is major participation by undergraduate students in programs of theoretical studies, data analysis, and the development of new instruments.

For further information, contact the director, Professor Jacqueline N. Hewitt, Room 37-241, 617-253-7501. http://space.mit.edu/

MIT Portugal Program
The MIT Portugal Program (MPP) was launched in October 2006 by the Portuguese Ministry of Science, Technology, and Higher Education as a large-scale international collaboration involving MIT and government, academia, and industry in Portugal, the aim being to develop leading-edge higher education and research programs related to engineering systems. The program is supported by a national initiative involving Portuguese universities and research centers, which, together with MIT, targets bioengineering systems, sustainable energy systems, engineering design and advanced manufacturing, and transportation systems as key areas for economic development and societal impact.

MIT Portugal has developed four PhD, one master’s, and three advanced studies programs in select Portuguese universities, as well as joint research projects involving faculty and students from MIT and Portugal.

MPP initiatives include faculty and students from MIT departments in all five schools at the Institute. MIT faculty regularly teach PhD or master’s courses in Portugal, either in person or via videoconference. MIT students working with these MIT faculty make research trips to Portugal to enhance collaborative relationships on joint projects and serve as research (and occasionally teaching) assistants to these faculty members. In addition, MPP has occasionally developed internship opportunities for MIT students to conduct research related to their work at Portuguese companies.

MIT Portugal offers opportunities for MIT students in graduate research collaboration and postdoctoral research as well as sponsored lectures and public colloquia on engineering systems.

For further information, contact the program’s assistant director, Jennifer Kratochwill, Room E40-221, 617-253-5738. http://www.mitportugal.org/

MIT Professional Education
MIT Professional Education provides short courses, semester or longer learning programs, and customized corporate programs for science and engineering professionals at all levels. Taught by renowned faculty from across the Institute, MIT Professional Education programs offer profession-
Professional Education will work with companies to match their needs with combining topics from both technology and management fields. MIT Courses are generally focused on scientific and technical leadership, programs designed to meet company-specific training needs, and range of evolving technologies. Courses combine MIT’s breakthrough research professionals wishing to gain new career tools and insights about the impact solving, laboratory work, and collaborative projects among participants, more than 50 courses in two-to-five day sessions, primarily in the summer. matching their abilities and ambition.

**Career Reengineering Program (http://career-reengineering.mit.edu/).** This MIT faculty-designed program helps talented professionals prepare for technical career re-entry. The part-time program incorporates career and personal development, a technical skills refresher, a semester-long MIT course, and an internship or research project. Students have access to the same campus resources as full-time MIT students. They complete the program with either a job or a strategic plan to find a professional job matching their abilities and ambition.

**Short Programs (http://shortprograms.mit.edu/).** Short Programs offers more than 50 courses in two-to-five day sessions, primarily in the summer. Classes may involve lectures, discussions, readings, interactive problem solving, laboratory work, and collaborative projects among participants, faculty, and peers. These intensive courses are designed for busy professionals wishing to gain new career tools and insights about the impact of evolving technologies. Courses combine MIT’s breakthrough research with insights from industry, government, and academic participants. Some courses can be offered at company sites for groups of 25 or more.

**Custom Programs (http://customprograms.mit.edu/).** These are programs designed to meet company-specific training needs, and range from a single day to a year-long sequence of sessions, on or off campus. Courses are generally focused on scientific and technical leadership, combining topics from both technology and management fields. MIT Professional Education will work with companies to match their needs with custom curricula from MIT faculty who have in-depth expertise in relevant disciplines.

For more information about MIT Professional Education, contact Clara Piloto, Room 35-433, 617-253-3760, fax 617-258-8831. 

http://professionaleducation.mit.edu/

**MIT Program in Art, Culture and Technology**

The MIT Program in Art, Culture and Technology (ACT) focuses on the intersections of art, culture, and technology through performance, sound, video/film, photography, interrogative and eco-design, as well as experimental media and new genres. ACT’s academic and research initiatives reflect the mission of the program, which is to operate as a critical studies and production-based laboratory connecting the arts with an advanced technological community. ACT emphasizes both knowledge production and knowledge dissemination. In the tradition of artist and educator Gyorgy Kepes, founder of MIT’s Center for Advanced Visual Studies (CAVS) and an advocate of “art on a civic scale,” ACT believes in artistic leadership as a vital voice that can initiate change, a critically transformative view of the world, and a civil responsibility to enrich cultural discourse.

ACT is an academic program situated in the Department of Architecture and is also a center that reports directly to the dean of the School of Architecture and Planning. ACT is home to the CAVS archive, hosts ACT research fellows, and organizes public events, exhibitions, and lectures.

The Future/Living Archive Project seeks to preserve and develop publicly accessible materials in the CAVS archive and to expand it by the addition of the Visual Arts Program archive and new content created by the ACT program. The CAVS archive contains historically significant materials concerning collaborative and time-based productions related to the work of nearly 100 internationally recognized artist-fellows over the past 44 years. ACT faculty, fellows, and students engage in advanced visual studies and research by implementing both an experimental and systematic approach to creative production and transdisciplinary collaboration. ACT seeks to connect research and curriculum through thematic clusters such as “Artistic Interventions: Creative Response to Conflict and Crisis,” “Art, Culture and Public Sphere,” “Interrogative and Eco-design,” and “The Future of Body.”

For further information, contact ACT, Room E15-212, 617-253-5229, fax 617-253-3977, act@mit.edu. 

http://act.mit.edu/

**MIT Sea Grant College Program**

Through innovative research, education, and outreach programs, MIT Sea Grant promotes the sustainable development and science-based stewardship of Massachusetts’ marine and coastal resources. We are part of the federally funded National Sea Grant College Program, a network of 32 programs in coastal states administered by the National Oceanic and Atmospheric Administration.

Current areas of research include artificially intelligent vehicles, sensor development, advanced ship-systems and hull design, underwater communications, coastal management, and invasive species detection and prevention. The program is home to the Autonomous Underwater Vehicles (AUV) Laboratory, which has been a leader in the development and testing of state-of-the-art, low-cost AUVs since its start in 1990. We also host the Design Lab which specializes in advanced naval architecture modeling and development. Education for K-12 and information outreach to local policy makers and the general public are also integral components of our program.

MIT Sea Grant provides research funding through an annual competition for professors and scientists involved in marine-related research. Graduate and undergraduate students participate in most Sea Grant research projects, and support is available for UROP projects.

Sea Grant also sponsors symposia and workshops, publishes reports, and works with local governments, businesses, and organizations to transfer technology and information to a wide range of audiences.

For more information about MIT Sea Grant, contact the director, Professor Chryssostomos Chryssostomidis, Room E38-300, 617-253-7131. 

http://seagrant.mit.edu/

**Nuclear Reactor Laboratory**

The MIT Nuclear Reactor Laboratory (NRL) is an interdepartmental center that operates a 6 MW research reactor. NRL has a distinguished history of providing faculty and students from MIT and other institutions with a state-of-the-art neutron source as well as a highly efficient and well-organized infrastructure to facilitate its use.
NRL is equipped with a wide variety of sample irradiation facilities, with fast and slow neutron fluxes up to 10^4 and 5x10^3 per cm^-2 per second; temperature-controlled in-pile facilities, a neutron diffractometer; and a fission converter facility. In-pile loops that closely simulate the environment in light water power reactors are available for corrosion and irradiation damage testing. An in-pile high-temperature irradiation facility for advanced materials studies has been successfully demonstrated to operate up to 1500°C. An excellent medical irradiation facility with a clinically useful epithermal beam is available for patient and animal irradiations.

Other experimental facilities and instrumentation include radiochemistry laboratories; hot cells for dismantling or testing; a shielded hot box for handling and nondestructive testing of radioactive materials; nuclear detection equipment; delayed and prompt gamma activation analysis facilities; an inductively coupled plasma spectrometer (ICP-OES); and a materials characterization laboratory. A thermal hydraulic lab was established with the Nuclear Science and Engineering Department to study heat transfer properties of nanofluids for nuclear reactor and other thermal management applications.

Current research topics include applications of nuclear trace analysis to problems in the physical and engineering sciences, life sciences, geosciences, and the environment; radiation effects on materials; advanced fuels irradiation; dose and corrosion reduction in power reactors; reactor engineering; instrumentation for neutron detection; nuclear medicine; and isotope production.

Undergraduates can be involved in the operation of the reactor by completing the reactor operator training program, which can lead to being employed part-time by the NRL as an NRC-licensed reactor operator, and/or utilize the reactor in research activities through special projects or senior theses. In addition, graduate thesis research can be carried on in the various research areas mentioned above.

A current summary report describing NRL activities in greater detail is available. For information, inquire at the office of the director, Dr. David E. Moncton, Room NW12-204, 617-253-8883.

Operations Research Center
The Operations Research Center (ORC) provides academic and research opportunities for graduate students and faculty interested in an interdisciplinary field that draws upon ideas from engineering, management, and mathematics in order to apply scientific methods to decision making. ORC includes faculty participants from the Sloan School of Management, as well as from the departments of Electrical Engineering and Computer Science, Aeronautics and Astronautics, Mathematics, Civil and Environmental Engineering, Mechanical Engineering, Urban Studies and Planning, and Economics. Forty-seven faculty and 54 graduate students are affiliated with the center.

The center coordinates master’s and PhD programs in operations research, which provides a strong background in theory as well as the practical techniques used in building models for a wide variety of applications.

For further information about the Operations Research Center and its degree programs, contact Laura Rose, Room E40-143, 617-253-9303, lrose@mit.edu.

Picower Institute for Learning and Memory
The Picower Institute for Learning and Memory is an interdisciplinary research entity within MIT’s School of Science, with faculty members holding academic appointments in the Department of Brain and Cognitive Sciences, the Department of Biology, or both.

The Picower Institute’s mission is to unravel the mechanisms that drive human learning and memory, as well as related functions such as perception, attention, and consciousness. The institute offers exciting research opportunities from undergraduate to postdoctoral levels in molecular, cellular, and genetic biology, as well as in systems biology, which explores the cognitive system at the neural circuit and systems level.

Picower Institute investigators explore:

- How memory is formed through genetic, molecular, and cellular neural circuits and neural systems
- How memories of personal experiences are used in daily life and in dreams
- How neurons form synaptic connections and how those connections transmit information and change with experience
- The surprising ability of certain species to grow new brain cells in adulthood and the extraordinary plasticity or adaptability of the developing and adult brain
- The intricacies underlying the executive functions of the cerebral cortex

The institute’s highly collaborative, cross-disciplinary strategy spawns exciting joint projects among its various laboratories. Many Picower faculty also are inventors of unique technologies and techniques that are redefining the practice of neuroscience.

Key Picower Institute discoveries are shedding light on disorders ranging from mental retardation and autism to Alzheimer’s, Huntington’s, and Parkinson’s disease, schizophrenia, epilepsy, brain injury, and stroke.

For further information, contact the director, Professor Li-Huei Tsai, Room 46-4235A, 617-324-1660, lhtsai@mit.edu.

Plasma Science and Fusion Center
The timely development of practical fusion energy in the 21st century is arguably one of the most important challenges facing the scientific and engineering community worldwide. The Plasma Science and Fusion Center provides a focus for experimental and theoretical studies in plasma science, magnetic and inertial fusion research, and the development of related enabling technologies. The center fosters independent creativity and provides the intellectual environment for the educational training of students, research scientists, and engineers. Research activities at the Plasma Science and Fusion Center fall into five major programmatic divisions as described below.

The Alcator C-Mod Project is developing a basic understanding of the stability and transport properties of high-temperature magnetically confined toroidal plasmas at reactor-relevant conditions. Alcator C-Mod, a world-class divertor tokamak, is a compact, high-magnetic-field device (up to 8 Tesla) with record-high plasma pressure and particle densities. C-Mod’s present research program is aimed at understanding energy and particle transport at magnetic fields, plasma densities, and first wall power loadings comparable to those of future fusion reactors. In addition, it
seeks to optimize plasma performance with RF heating and non-inductive current profile control using high-power RF transmitters (8 MW at 40–80 MHz) and microwaves (3 MW at 4.6 GHz frequency).

The Physics Research Division is developing the basic experimental and theoretical understanding of magnetically confined plasmas, including experimental research in magnetic reconnection in plasmas, and development of advanced and novel plasma diagnostics. The experimental facilities in this division include the Versatile Toroidal Facility for basic plasma science research. Scientists, students, and faculty in this division also carry out world-renowned theoretical research.

The High-Energy-Density Physics Division designs and implements experiments on national facilities, such as the OMEGA laser facility at the University of Rochester Laboratory for Laser Energetics, and the National Ignition Facility at Lawrence Livermore National Facility. This division discovered the existence of megagauss magnetic fields in laser-compressed pellets. This division also performs related theoretical calculations to study and explore the nonlinear dynamics and properties of plasmas in inertial fusion and those under the extreme conditions of density (~1000 g/cc), pressure (~100 gigabar), and field strength (~megagauss). Most recently the division has conducted pioneering nuclear science experiments using high-energy-density plasmas, ushering in a new and exciting field of research, plasma nuclear science, blending the separate disciplines of plasma and nuclear physics.

The Waves and Beams Division conducts experimental and theoretical research on the physical principles of novel sources of coherent radiation ranging from the microwave to the infrared, optical, and X-ray regions of the electromagnetic spectrum. Current research includes work on the gyrotron (or cyclotron resonance maser), a novel source of millimeter wave and terahertz radiation using high magnetic fields. The division also conducts research on novel concepts for high-gradient acceleration of electrons to demonstrate the principles required for future generations of electron linear accelerators. The experimental research utilizes a 25 MeV accelerator to investigate high-gradient acceleration of electrons and coherent radiation by femtosecond electron bunches.

The Fusion Technology and Engineering Division provides critical engineering support to the national fusion energy sciences program for both operating magnetic confinement fusion experiments and advanced fusion design projects. The division has extensive experience in design, analysis, development, and fabrication of advanced high-field copper and superconducting magnet technology. Present research is focused on developing second-generation high-temperature superconductors for high-field, high-current cables for fusion magnets, and for applications of superconducting DC power transmission and distribution. The division is also developing very high-field, compact cyclotron accelerators for applications such as proton radiotherapy for cancer treatment, active detection of strategic nuclear materials for protection against weapons of mass destruction, and variable energy, heavy-ion accelerators for fusion materials research.

Many academic departments are affiliated with PSFC, including Physics, Nuclear Science and Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, Chemical Engineering, and Aeronautics and Astronautics. The center’s programs and laboratories provide excellent forums for training students and professional researchers, and offer world-class research facilities to faculty members from many departments. Sixty-three graduate students are currently involved at all levels of thesis work. Undergraduates also can participate through the Undergraduate Research Opportunities Program.

For further information contact the director, Professor Miklos Porkolab, Room NW16-288, 617-253-8448, fax 617-253-0238, porkolab@psfc.mit.edu. http://www.psfc.mit.edu/

Research Laboratory of Electronics

The Research Laboratory of Electronics (RLE) was founded in 1946 as the first of the Institute’s great modern interdepartmental research centers. Today, it is one of MIT’s largest, as well as the most diverse in intellectual interests.

RLE research is focused on seven major themes:
- Atomic physics
- Circuits, systems, signals, and communications
- Energy, power, and electromagnetics
- Multiscale bioengineering and biophysics
- Nanoscale science and engineering
- Photonic materials devices and systems
- Quantum computation and communication

Sixty-eight principal investigators—of whom 59 are MIT faculty members—direct RLE’s research projects. These faculty members are drawn from nine MIT departments and divisions: Biological Engineering, Electrical Engineering and Computer Science, Engineering Systems, Materials Science and Engineering, Mathematics, Mechanical Engineering, Nuclear Science and Engineering, Physics, and the Harvard-MIT Division of Health Sciences and Technology.

More than 340 MIT graduate and undergraduate students—also drawn from these departments and divisions—make RLE one of the primary environments for student learning at MIT. In fact, it is the combination of forefront research with student participation across multiple academic disciplines that characterizes the RLE culture.

In 2009, the Laboratory for Electromagnetic and Electronic Systems (LEES) was merged into RLE as part of a growing emphasis on energy-related research. Researchers affiliated with LEES are pioneers in understanding, on one hand, the theoretical basis of advanced electrical power and energy applications, and on the other, the component, circuit, and system technologies required to make such applications into practical realities.

RLE’s research efforts are supported by the most diverse sponsor base at MIT. Principal sponsors include the Department of Defense, National Institutes of Health, National Science Foundation, Department of Energy, industry, and nonprofit foundations and organizations.

In addition, a significant share of RLE’s activities is self-funded from gifts and from the discretionary resources of the laboratory and its principal investigators. Approximately a third of RLE’s activities involves extramural collaborations with universities, institutions, and industry, making the laboratory one of MIT’s principal points of connection with peer institutions, government, and the business world.

Nearly all RLE activities take place at MIT’s main campus in Cambridge. Some also take place at the Massachusetts Eye and Ear Infirmary in Boston.

For further information, contact RLE Headquarters, Room 36-413, 617-253-2519. http://www.rle.mit.edu/
Simons Center for the Social Brain
The Simons Center for the Social Brain at MIT was established on January 1, 2012, with the mission of investigating the neural mechanisms underlying social cognition and behavior, and to translate this knowledge into better diagnosis and treatment of autism spectrum disorders.

Neural correlates of social cognition and behavior exist in diverse species, and the underlying mechanisms will be studied in both humans and relevant model organisms and systems. We expect that experimental approaches will take advantage of strengths at MIT in genetics and genomics, molecular and cell biology, analyses of neural circuits and systems, cognitive psychology, mathematics, and engineering.

The center’s goals are to develop MIT-wide programs on genetics and gene discovery, mechanisms and models, cognitive neuroscience, and translation and therapeutics. MIT researchers can contribute uniquely to understanding autism and related brain disorders through the development of novel tools and technologies and advancing new computational and theoretical approaches.

The center supports these programs and themes through seed funds for new investigators proposing novel collaborative research, a postdoctoral fellows program, and support for graduate students and undergraduate researchers. We also work closely with researchers and clinicians at neighboring hospitals and universities.

For further information, contact the director, Professor Mriganka Sur, Room 46-6237, 617-253-8784, msur@mit.edu.

http://web.mit.edu/scsb/

Singapore-MIT Alliance
The Singapore-MIT Alliance (SMA) is a global partnership in graduate education created by MIT, the National University of Singapore, and Nanyang Technological University. Setting a new standard for international collaboration in graduate research and education, the alliance educates young engineers to serve as leaders in a technologically advanced economy, and creates a cohort of students and faculty with creativity and entrepreneurial spirit.

All five SMA-2 programs—Advanced Materials for Micro- and Nano-Systems, Chemical and Pharmaceutical Engineering, Computational Engineering, Computational and Systems Biology, Manufacturing Systems and Technology—had their final intake of new dual master’s students. All five programs continue to have engagement with PhD students and active research programs.

For more information about SMA, contact the executive director, John C. Desforge, Room 8-407, 617-452-3014.

http://web.mit.edu/sma/

Singapore-MIT Alliance for Research and Technology
The Singapore-MIT Alliance for Research and Technology (SMART) Centre is a major new research enterprise established by MIT in partnership with the National Research Foundation of Singapore (NRF). The SMART Centre serves as an intellectual hub for research interactions between MIT and Singapore at the frontiers of science and technology. The goals and aims of the SMART Centre are to:

- Identify and carry out research on critical problems of societal significance and develop innovative solutions through its Interdisciplinary Research Groups (IRGs)
- Become a magnet for attracting and anchoring global research talent to Singapore
- Develop robust partnerships with local universities and institutions in Singapore
- Engage in graduate education by co-advising local doctoral students and postdoctoral associates
- Help instill a culture of translational research, entrepreneurial and technology transfer through the SMART Innovation Centre

Established in 2007, the SMART Centre further expands and develops this partnership between MIT and Singapore and allows faculty, researchers, and graduate students from MIT to collaborate with their counterparts from universities, polytechnics, research institutes and industry in Singapore and in Asia.

The SMART Centre is MIT’s first research center outside of Cambridge, MA, and its largest international research endeavor. The center is also the first entity in the Campus for Research Excellence and Technological Enterprise currently being developed by NRF.

SMART Interdisciplinary Research Groups
The SMART Centre allows researchers from MIT to collaborate with their counterparts from universities, research institutes and industries in Singapore and Asia to perform interdisciplinary, experimental, computational and translational research. With many MIT faculty members, postdoctoral fellows, PhD students, and staff participating at SMART, these IRGs are helping promote a vibrant knowledge-based atmosphere in Singapore.

Five Interdisciplinary Research Groups are under the SMART Centre, each headed by a senior MIT faculty member: Infectious Disease, the Centre for Environmental Sensing and Modeling, BioSystems and Micromechanics, Future Urban Mobility, and Low Energy Electronic Systems.

SMART Centre Graduate Fellowship Programme
The Graduate Fellowship Programme is open to currently enrolled first-year students and entering doctoral students from the Nanyang Technological University (NTU) and the National University of Singapore (NUS). Its goal is to attract and retain the best and most talented doctoral students from Singapore, the region and beyond, giving them the unique opportunity to be involved in strategic research at the SMART Centre and to work with faculty members from MIT, NTU, and NUS.

Students selected for the programme receive up to four years of full tuition fees at the student’s home university, a monthly stipend, and a travel grant for a six-month residency at MIT.

SMART Centre Undergraduate Research Opportunities Programme
The SMART Undergraduate Research Fellowship Programme (SMURF) allows undergraduates from MIT, NTU, and NUS to participate in an MIT faculty member’s research projects at the SMART Centre and interact with students, researchers, and faculty members. Students selected spend a summer at the SMART Centre. Each undergraduate has an MIT faculty member as a mentor/co-advisor and the undergraduate has access and use of the faculty’s laboratory and equipment.
Students are paid a competitive stipend; those from MIT also have their travel and accommodation paid for. The aim of the SMART SMURF Programme is to expose undergraduate students to research experiences involving an internationally diverse group of investigators.

**SMART Centre Postdoctoral Research Fellows Programme**

The highly selective Postdoctoral Research Fellows Programme aims to attract exceptionally talented postdoctoral researchers to Singapore. These awards provide a unique opportunity for recent PhD graduates to participate in the SMART Centre in Singapore. The awards, to be given annually, are open to those with less than three years postdoctoral experience.

In contrast to typical postdoctoral programmes where the postdoctoral works for a supervisor on a project defined by the supervisor, this programme allows the investigators to conduct research into questions of their own interest. The fellowship recipient is able to conduct research of him/her own choice in Singapore within, but not necessarily tied closely to, a current project in one of the existing SMART IRGs. In addition to a generous stipend each fellow also receives a research grant and travel funds.

For more information about SMART, contact the executive director, John C. Desforge, Room 8-407, 617-452-3014.

[http://smart.mit.edu/](http://smart.mit.edu/)

**Sociotechnical Systems Research Center**

MIT's Sociotechnical Systems Research Center (SSRC) is an interdisciplinary research center addressing global technology, health, and policy issues through partnerships with industry, government, and academia. SSRC's mission is to develop new knowledge, advanced technological strategies, and innovative partnerships that support global industrial growth, social well-being, and environmental health.

SSRC research focuses on complex systems problems at the intersection of social, natural, and technological systems. Current collaborations address issues in aerospace, automotive, engineering and construction, healthcare, information quality, materials systems, and mobility. Center programs include the Center for Biomedical Innovation, Center for Engineering Systems Fundamentals, Ford-MIT Alliance, Geospatial Data Center, Lean Advancement Initiative, Materials Systems Laboratory, MIT Information Quality, and the Systems Engineering Advancement Research Initiative.

For further information, contact the director, Professor Deborah Nightingale, Room E38-670, dnight@mit.edu.

[http://ssrc.mit.edu/](http://ssrc.mit.edu/)

**Spectroscopy Laboratory**

The George Russell Harrison Spectroscopy Laboratory is dedicated to advancing knowledge of the structure and dynamics of atoms and molecules and the properties of liquids, solids, and biological materials utilizing the techniques of lasers and modern spectroscopy.

An interdisciplinary department in the School of Science, the Spectroscopy Laboratory encourages participation and collaboration among staff members in various disciplines of science and engineering. At present, faculty and staff from the Departments of Chemistry, Physics, Chemical Engineering, Electrical Engineering and Computer Science, and the Harvard-MIT Division of Health Sciences and Technology pursue research projects in the laboratory. In addition, researchers from both the United States and abroad participate in the projects sponsored by the laboratory.

The Spectroscopy Laboratory houses an extensive collection of lasers for spectroscopic research. The resources are organized into the following major laboratories: pulsed visible/UV spectroscopy and kinetics; combustion kinetics; tri-modal biomedical spectroscopy and imaging; Raman microscopy for cellular investigations and spectroscopy for trans-dermal glucose detection and carbon nanotube studies; low-coherence interferometry; spectroscopy of quantum dots; multidimensional vibrational spectroscopy; bioinstrumentation engineering analysis and microscopy; and picosecond time-resolved spectroscopy. Major equipment includes excimer and Nd:YAG-based pulsed dye lasers, femtosecond Ti:sapphire lasers, ion laser-pumped dye lasers, CW Raman spectrometers, streak camera; and various phase microscopes.

The laboratory is a resource for researchers in both physical science and biomedical optics. The Laser Biomedical Research Center (LBRC), supported by a grant from the National Institutes of Health, is devoted to spectral diagnosis of disease and advancements in imaging techniques for cell biology and medicine. LBRC facilities are made available to researchers in biology and biomedicine from universities, industry, and medical institutions.

Current research activities in the laboratory include high-resolution laser spectroscopy of excited vibrational and electronic molecular states, quantum dots, characterization of nanotubes, acoustic and thermal properties of high-pressure materials, carbon-centered radicals with O₂, kinetics of intermediates in organo-metallic complexes, proton-coupled electron transfer studies, two-photon fluorescence spectroscopy-based study of neuronal plasticity and mechanotransduction processes and diagnosis of disorders of human biological tissue, in particular detection and monitoring of important diseases such as cancer and diabetes using Raman, diffuse reflectance, and fluorescence spectroscopy, and cell biology investigations using phase microscopy.

Many graduate and undergraduate students perform thesis research in the laboratory; Undergraduate Research Opportunities Program projects are offered in many areas of laser research.

For further information, contact the lab at Room 6-205, 617-452-3422.


**Technology and Development Program**

The Technology and Development Program (TDP) provides a focus at MIT for interdisciplinary research and education related to the role of science and technology in the socioeconomic growth of newly industrialized countries.

TDP promotes an awareness among faculty and students of the relationships among science, technology, and development; provides a focal point for the activities of faculty, students, and visiting scholars interested in the field of technology and development; and serves as a resource for organizations outside MIT (government, academic, private sector) that wish to explore the Institute’s understanding of socioeconomic and technological challenges facing the newly industrialized nations.

TDP is administered by faculty executive committees which oversee the activities of each program. The primary emphasis of each TDP program is on institution building. Through research, education, and industrial outreach activities, the program provides opportunities for industry, gov-
Part can petition for a major departure in WGS. The curriculum includes a core engineering, and literature. as diverse as anthropology, history, biology, psychology, performance, to incorporate the experiences, perceptions, and intellectual contributions of researchers about the role of gender in all academic disciplines as well as and graduate students. The primary objective of WGS is to promote new opportunities for interdisciplinary study and research for both undergraduate and interdisciplinary collaborations for their work in their vast fields of education, which includes a Master of Engineering in Logistics, described in Engineering Systems Division in Part 2, and a Master of Science and a Doctor of Philosophy in Transportation, described in Interdisciplinary Graduate Programs in Part 3. At the undergraduate level, we have introduced transportation technology and systems courses to our curriculum in support of flexible engineering degrees with a transportation concentration.

Our regular seminars highlighting current MIT and external transportation research engage this community of faculty, research staff, and students. At these seminars, students are introduced to potential applications and interdisciplinary collaborations for their work in their vast fields of transportation in academia, government, and industry. Students also have a community within the Institute-wide Transportation Club, which has over 300 members.

Women’s and Gender Studies Program
The Program in Women’s and Gender Studies (WGS) offers unique opportunities for interdisciplinary study and research for both undergraduate and graduate students. The primary objective of WGS is to promote new research about the role of gender in all academic disciplines as well as to incorporate the experiences, perceptions, and intellectual contributions of women into existing curricula. It offers new perspectives in fields as diverse as anthropology, history, biology, psychology, performance, engineering, and literature.

Undergraduates can choose a concentration or a minor in WGS and can petition for a major departure in WGS. The curriculum includes a core subject, Introduction to Women’s and Gender Studies, and a selection of subjects from many departments at the Institute. Special independent study topics and UROP projects can be arranged.

Several regular subjects are offered for graduate credit, and graduate students may also enroll in courses offered through the Graduate Consortium in Women’s Studies. See the section on Graduate Education in Part 1 for more information.

For more information, contact the coordinator, Heidy M. González, Room 14E-316, 617-253-8844.

http://web.mit.edu/wgs/

OTHER AFFILIATIONS

Broad Institute of MIT and Harvard
Founded in 2003 and launched in 2004, the Broad Institute of MIT and Harvard seeks to transform medicine by empowering creative and energetic scientists of all disciplines from across the MIT, Harvard, and the Harvard-affiliated hospital communities to work together to address even the most difficult challenges in biomedical research.

Investigators at the Broad Institute come from all of its partner institutions, many of whom are faculty members at MIT or Harvard. Currently there are ten core faculty members with their primary labs located at the Broad, and over 160 associate members, with their primary labs located at one of the universities or hospitals.

The Broad Institute is also home to many postdoctoral and graduate students who perform some or all of their research at the Broad Institute, although graduate students earn their degrees from their respective home institutions. In addition, the Broad Institute offers numerous research opportunities for undergraduate and high school students. To learn more about these programs, visit the Broad website.

The Broad Institute primary research labs are at 7 Cambridge Center, across the street from MIT’s Biology Department and adjacent to the Whitehead Institute, at 320 Charles Street, and at 301 Binney Street.

Further information may be obtained by contacting the Broad Institute Communications Office at 7 Cambridge Center, Cambridge, MA 02142, 617-714-7000.

http://www.broadinstitute.org/

Draper Laboratory
The Charles Stark Draper Laboratory (formerly the Instrumentation Laboratory) separated from MIT in 1973 to become an independent not-for-profit research and educational organization.

Mechanisms exist to permit joint research activities and to allow Draper Lab to continue its unique contributions to the Institute’s educational programs. Opportunities are available in the Course 6-A program, Space Grant, other programs, and for part-time employment. Research assistantships, denoted as Draper Laboratory Fellows, for SM and PhD candidates are described in the Graduate Education Manual. Copies are available from the Office of the Dean for Graduate Education, Room 3-138, 617-253-4860, and from department graduate offices.

Draper Lab’s pioneering work in instrumentation has led to the development of highly precise sensors and ultra-reliable systems on which the world depends for safe and accurate guidance, navigation, and control. Much of Draper’s current research and development focuses on problems
that arise in the measurement, analysis, simulation, and control of complex dynamic systems. This research and development covers a wide range of application areas, including guidance, navigation and control, miniature low power systems, complex reliable systems, autonomous systems, information and decision systems, biomedical and chemical systems, secure networking and communications, energy systems, and commercial space systems.

A number of MIT faculty members maintain a close association with Draper Lab, and thesis research opportunities exist that fulfill the residency requirement for an MIT degree. Students are in direct daily contact with the Draper technical staff of engineers and scientists, and thus learn to appreciate the economic and human as well as the technical aspects of a system. Undergraduate and graduate students also may be employed by the laboratory and work directly on a project.

Adjacent to the main campus, Draper Laboratory is located at 555 Tech Square, Cambridge, MA 02139-3582. Information may be obtained by contacting the Draper Office of Education at 617-258-2393, or by sending an email to education@draper.com.

http://www.draper.com/

Whitehead Institute for Biomedical Research

Whitehead Institute provides educational and research opportunities for graduate and undergraduate students in the biological sciences.

A nonprofit, independent research institution, Whitehead is affiliated with MIT through its members, who hold faculty positions at MIT. A small number of junior investigators also hold positions at Whitehead Institute as part of the Whitehead Fellows program.

Whitehead Institute’s research excellence is nurtured by the collaborative spirit of its faculty and the creativity and dedication of its graduate students and postdoctoral scientists. Whitehead’s primary focus is basic science, with an emphasis on molecular and cell biology, genetics and genomics, and developmental biology. Specific areas of inquiry at Whitehead include cancer, transgenic science, stem cells, regenerative biology, genetics, genomics, membrane biology, vertebrate development, and neurological disorders.

Whitehead Institute is engaged in research collaborations with numerous academic and industrial partners. These partnerships expand the scope of Whitehead research, as well as aid the translation of basic research into advances in disease prevention, diagnosis, and therapy.

Whitehead Institute also supports a suite of programs that foster high school science education, and public engagement with science and technology. Students and postdoctoral candidates interested in science education and community outreach are encouraged to participate in these programs.

Each year, a number of graduate students pursue PhD degrees at Whitehead Institute through the Department of Biology. Undergraduate students pursue research objectives through MIT’s Undergraduate Research Opportunities Program.

Further information may be obtained through Communications and Public Affairs, Whitehead Institute, 9 Cambridge Center, Cambridge, MA 02142-1479, 617-258-5183.

http://www.whitehead.mit.edu/
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About the Cover

D-Lab: Development through Dialogue, Design and Dissemination

D-Lab is part of a growing and exciting constellation of MIT programs that are committed to using technology, design and educational resources to pursue the eradication of poverty worldwide. Over the past 10 years, D-Lab has evolved to include 16 courses, fieldwork projects, partners, research, programs and K-12 outreach.

D-Lab courses address developing world needs for everything ranging from health products to schools, mobile technology to clean energy, and grain-mills and oil presses to waste management. Other subjects cover the principles of collaborative, user-centric design; cross-cultural communication and biodiversity; as well as business venture development, supply chains, management and distribution. Many D-Lab classes provide an option for fieldwork during the Independent Activities Period in January, over spring break or during the summer. A new study abroad program in collaboration with Global Education and Career Development will offer a semester-long blend of classroom and field experiences, with deep community engagement.

Other D-Lab programs include Innovations in International Health (developing technologies in a multidisciplinary research environment to address the needs of patients and healthcare workers in resource-poor settings), the annual International Development Design Summit, the Scale-Ups program for technology dissemination, a new Technology Evaluation Program, and the Creative Capacity Building program which has developed a methodology and training for people living in poverty to harness individual creativity and ingenuity to solve local problems.

D-Lab recently relocated to spacious new headquarters in N51 with workshops, classrooms, meeting spaces and offices.


Credits

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Front cover, main photo:
Economics student Viral Modi (Class of 2013) measures the time it takes for charcoal made out of pine needle to heat two liters of water in order to compare it to other charcoal, wood, and liquefied petroleum gas, in Avani, India. On the left, Chanchal Singh, a technical supervisor from AVANI, a D-Lab community partner, looks on. Photo by Nathan Cooke.

Back cover, inset:
Two freshmen students in the fall 2010 D-Lab: Discovery course present their hygienic hands-free device for hand-washing. Photo by Nathan Cooke.

Back cover, main photo:
Charcoal technology demonstration at a local farmers’ cooperative in Uganda, 2011. Photo by Nse Umoh MCP ’12.

Back cover, inset:
Mechanical Engineering student Fareeha Safir (Class of 2013) and Materials Science and Engineering Arfa Aijazi (Class of 2013) observe the testing of a hand-powered grain mill at the weekly village meeting, Kikwe, Tanzania, 2011. Photo by Colin McSwiggen ’11 (Physics).

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Welcome to MIT

All MIT buildings are designated by 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 7-121, the figures preceding the hyphen give the building number, the first number following the hyphen, the floor, and the last two numbers, the room.

Please refer to the building index on the reverse side of this map, if the room number is unknown.

An interactive map of MIT can be found at http://whereis.mit.edu/.

Parking

= public parking (pay lots)

= MIT permit parking

= MIT parent parking

MIT Campus Map

If the room number is unknown.

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