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, 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 Coordinator of Staff Diversity Initiatives/Affirmative Action, Room E19-215, 617-253-1594. In the absence of the Vice President for Human Resources or the Coordinator of Staff Diversity Initiatives/Affirmative Action, 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.

*The ROTC programs at MIT are operated under Department of Defense (DOD) policies and regulations, and do not comply fully with MIT’s policy of nondiscrimination with regard to sexual orientation. MIT continues to advocate for a change in DOD policies and regulations concerning sexual orientation, and will replace scholarships of students who lose ROTC financial aid because of these DOD policies and regulations.

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 for Institute Affairs 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.

Copies of the Student Directory and Faculty & Staff Directory, issued in November, are available to MIT students, faculty, and staff in mailrooms across campus. The online People Directory can be searched at http://web.mit.edu/people/.


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 E28-100, 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/.
## CONTENTS

<table>
<thead>
<tr>
<th>Part</th>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Degree Charts</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Welcome</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Academic Calendar</td>
<td>6</td>
</tr>
<tr>
<td>1</td>
<td>This Is MIT</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Overview</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Campus Life</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Undergraduate Education</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Graduate Education</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>Academic Procedures and Institute Regulations</td>
<td>70</td>
</tr>
<tr>
<td>2</td>
<td>Schools and Courses</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>School of Architecture and Planning</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>School of Engineering</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>School of Humanities, Arts, and Social Sciences</td>
<td>189</td>
</tr>
<tr>
<td></td>
<td>MIT Sloan School of Management</td>
<td>228</td>
</tr>
<tr>
<td></td>
<td>School of Science</td>
<td>239</td>
</tr>
<tr>
<td>3</td>
<td>Interdisciplinary Programs</td>
<td>274</td>
</tr>
<tr>
<td></td>
<td>Undergraduate Programs and Minors</td>
<td>276</td>
</tr>
<tr>
<td></td>
<td>Graduate Programs</td>
<td>283</td>
</tr>
<tr>
<td></td>
<td>Interdisciplinary Research and Study</td>
<td>299</td>
</tr>
<tr>
<td></td>
<td>Index</td>
<td>322</td>
</tr>
<tr>
<td></td>
<td>Campus Map</td>
<td>inside back cover</td>
</tr>
</tbody>
</table>

MIT Subject Descriptions are available online at [http://student.mit.edu/catalog/index.cgi](http://student.mit.edu/catalog/index.cgi)
Bachelor of Science Degree Requirements

**School of Architecture and Planning**
Art and Design/Course 4 86
Planning/Course 11 95

**School of Engineering**
Aerospace Engineering/Course 16-1 108
Aerospace Engineering with Information Technology/Course 16-2 108
Archaeology and Materials/Course 3-C 164
Biological Engineering/Course 20 119
Chemical-Biological Engineering/Course 10-B 126
Chemical Engineering/Course 10 124
Civil and Environmental Engineering/Course 1-A 137
Civil Engineering/Course 1-C 134
Computer Science and Engineering/Course 6-3 144
Electrical Engineering and Computer Science/Course 6-2 144
Electrical Engineering and Computer Science/Course 6-P 146
Electrical Science and Engineering/Course 6-1 144
Environmental Engineering Science/Course 1-E 135
Materials Science and Engineering/Course 3 162
Mechanical and Ocean Engineering/Course 2-OE 173
Mechanical Engineering/Course 2 170
Mechanical Engineering/Course 2-A 172
Nuclear Science and Engineering/Course 22 184

**School of Humanities, Arts, and Social Sciences**
Anthropology/Course 21A 193
Comparative Media Studies/Course CMS 195
Economics/Course 14 198
Foreign Languages and Literatures/Course 21F 202
History/Course 21H 206
Humanities/Course 21 207
Humanities and Engineering/Course 21E 208
Humanities and Science/Course 21S 208
Linguistics and Philosophy/Course 24-2 212
Literature/Course 21L 215
Music/Course 21M 217
Philosophy/Course 24-1 210
Political Science/Course 17 220
Science, Technology, and Society/Double Major/Course STS 223
Writing/Course 21W 226

**MIT Sloan School of Management**
Management Science/Course 15 231

**School of Science**
Biology/Course 7 242
Brain and Cognitive Sciences/Course 9 248
Chemistry/Course 5 254
Earth, Atmospheric, and Planetary Sciences/Course 12 258
Mathematics/Course 18 263
Mathematics with Computer Science/Course 18-C 265
Physics/Course 8 268
Welcome from the President

MIT has a distinctive mission and history that set us apart from other American universities. When the Institute was established almost 150 years ago, science had essentially no impact on the curriculum that was followed by most American university students. Our first president, William Barton Rogers, envisioned a new kind of academic institution—one that could, as he put it, “serve the times and the nation’s needs.”

Those principles have served us well, and today our work—in engineering, the natural and social sciences, the humanities and the arts—reaches people the world over. The Institute community extends far beyond Cambridge, embracing international partners and more than 100,000 alumni around the globe.

I believe the world has never needed MIT as much as it does now. The major challenges of our age are increasingly shaped by science and technology, and by daunting problems of quantitative analysis and complex synthesis. With MIT’s expertise in interdisciplinary problem solving, the Institute has a unique opportunity, and a deep obligation, to make a critical difference—by creating the innovations, fueling the economy, and educating the leaders the world needs now.

In addressing these needs, we draw on an unwavering drive toward excellence, a spirit of innovation, a culture of collaboration, and a commitment to making an MIT education accessible to all who have the talents and ambition to benefit from our programs.

If you know MIT well, I hope that you already share my enthusiasm for this vibrant, 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.

Susan Hockfield
President
**SEPTEMBER**

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tue</td>
<td>English Evaluation Test for international students, 9 am–12 noon.</td>
</tr>
<tr>
<td>7</td>
<td>Mon</td>
<td>Labor Day—Holiday</td>
</tr>
<tr>
<td>8</td>
<td>Tue</td>
<td>Registration Day—Fall Term</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of class days (Wed, Sep 9, through Thu, Dec 10): 13 Mon, 12 Tue, 13 Wed, 13 Thu, 12 Fri = 63 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deadline to change a Spring Term Exploratory subject to Listener status</td>
</tr>
<tr>
<td>9</td>
<td>Wed</td>
<td>Degree Application deadline for February SB and Advanced Degrees. $40 Late Fee ($75 after December 11).</td>
</tr>
<tr>
<td>11</td>
<td>Fri</td>
<td>Degree Application deadline. Signed Registration forms for all students due in Student Services Center. $40 Late Fee.</td>
</tr>
<tr>
<td>14</td>
<td>Mon</td>
<td>First day of classes</td>
</tr>
<tr>
<td>14–18</td>
<td>Mon–Fri</td>
<td>Career Week</td>
</tr>
<tr>
<td>15</td>
<td>Tue</td>
<td>2 pm Graduate Academic Performance Meeting</td>
</tr>
<tr>
<td>16</td>
<td>Wed</td>
<td>Faculty Officers recommend degrees to Corporation</td>
</tr>
<tr>
<td>17</td>
<td>Thu</td>
<td>11 am–6 pm Fall Career Fair</td>
</tr>
<tr>
<td>25</td>
<td>Fri</td>
<td>Minor Completion Date. Deadline for submission of Minor Completion form for final-term seniors. $40 Late Fee.</td>
</tr>
<tr>
<td>30</td>
<td>Wed</td>
<td>Last day to sign up for family health insurance or waive individual coverage, E23-308</td>
</tr>
</tbody>
</table>

**OCTOBER**

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Fri</td>
<td>Add Date. Last day to add subjects to Registration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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>
</tr>
<tr>
<td></td>
<td></td>
<td>Last day for graduate students to change a subject to or from P/D/F grading</td>
</tr>
<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 for sophomores to change a subject to or from Exploratory</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Late fee ($100) and petition required for students completing registration after this date</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Last day to petition for second SB for June or next September degree candidates</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Last day for June and September 2010 degree candidates to apply for double major</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>Deadline for completing cross-registration. $40 Late Fee for any petitions approved after this date.</td>
</tr>
<tr>
<td>12</td>
<td>Mon</td>
<td>Columbus Day—Holiday</td>
</tr>
<tr>
<td>13</td>
<td>Tue</td>
<td>Monday Schedule of Classes to be held</td>
</tr>
<tr>
<td>16–18</td>
<td>Fri–Sun</td>
<td>Family Weekend</td>
</tr>
<tr>
<td>26</td>
<td>Mon</td>
<td>Second-quarter Physical Education classes begin</td>
</tr>
</tbody>
</table>

**NOVEMBER**

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Wed</td>
<td>Veterans Day—Holiday</td>
</tr>
<tr>
<td>18</td>
<td>Wed</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>
</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></td>
<td></td>
<td>Last day to add half-term subjects offered in second half of term</td>
</tr>
<tr>
<td>26–27</td>
<td>Thu–Fri</td>
<td>Thanksgiving Vacation</td>
</tr>
</tbody>
</table>
**2009–2010**

**DECEMBER**

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tue</td>
<td>Online preregistration for Spring Term and IAP begins</td>
</tr>
<tr>
<td>4</td>
<td>Fri</td>
<td>Subjects with final exam—No test may be given and no assignment, term paper, or oral presentation shall fall due after this date.</td>
</tr>
<tr>
<td>10</td>
<td>Thu</td>
<td>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.</td>
</tr>
<tr>
<td>11</td>
<td>Fri</td>
<td>Last day of classes</td>
</tr>
<tr>
<td>14–18</td>
<td>Mon–Fri</td>
<td>Last day to drop half-term subjects offered in the second half of term</td>
</tr>
<tr>
<td>15–30</td>
<td>Tue–Wed</td>
<td>Final exam period</td>
</tr>
<tr>
<td>30</td>
<td>Wed</td>
<td>Spring preregistration deadline. Continuing students must initiate online preregistration by 5 pm on this date. $40 Late Fee ($75 after January 14).</td>
</tr>
</tbody>
</table>

**JANUARY**

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Mon</td>
<td>First day of January Independent Activities Period</td>
</tr>
<tr>
<td>5</td>
<td>Tue</td>
<td>Deadline for doctoral students to submit application, signed by department, to 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.</td>
</tr>
<tr>
<td>6</td>
<td>Wed</td>
<td>Term Summaries of Fall Term grades delivered to departments</td>
</tr>
<tr>
<td>7</td>
<td>Thu</td>
<td>1 pm First-Year Grades Meeting</td>
</tr>
<tr>
<td>8</td>
<td>Fri</td>
<td>Thesis due for doctoral degrees</td>
</tr>
<tr>
<td>12</td>
<td>Tue</td>
<td>Last day to petition for January Advanced Standing Exam</td>
</tr>
<tr>
<td>14</td>
<td>Thu</td>
<td>2 pm Graduate Academic Performance Meeting</td>
</tr>
<tr>
<td>15</td>
<td>Fri</td>
<td>5 pm Final deadline for continuing students to preregister online. $75 Late Fee.</td>
</tr>
<tr>
<td>18</td>
<td>Mon</td>
<td>Thesis due for degrees other than doctoral</td>
</tr>
<tr>
<td>20</td>
<td>Wed</td>
<td>Last day to go off the February degree list</td>
</tr>
<tr>
<td>21</td>
<td>Thu</td>
<td>Martin Luther King, Jr. Day—Holiday</td>
</tr>
<tr>
<td>27</td>
<td>Wed</td>
<td>English Evaluation Test for international students, 9 am–12 noon</td>
</tr>
<tr>
<td>29</td>
<td>Fri</td>
<td>Last day of January Independent Activities Period</td>
</tr>
</tbody>
</table>

**FEBRUARY**

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mon</td>
<td>Registration Day—Spring Term</td>
</tr>
<tr>
<td>2</td>
<td>Tue</td>
<td>Number of class days (Tue, Feb 2, through Thu, May 13): 12 Mon, 12 Tue, 14 Wed, 14 Thu, 13 Fri=65 days</td>
</tr>
<tr>
<td>3</td>
<td>Wed</td>
<td>Deadline to change a Fall Term Exploratory subject to Listener status</td>
</tr>
<tr>
<td></td>
<td></td>
<td>First day of classes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grades due in Registrar’s Office, 5-119, for work completed in IAP</td>
</tr>
<tr>
<td>Date</td>
<td>Event</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>5 Fri</td>
<td><strong>Registration deadline.</strong> Signed Registration forms for all students <strong>due</strong> in Student Services Center. $40 Late Fee.</td>
<td></td>
</tr>
<tr>
<td>5 Fri</td>
<td><strong>Degree application deadline</strong> for June SB and Advanced Degrees. $40 Late Fee ($75 Late Fee after April 3).</td>
<td></td>
</tr>
<tr>
<td>5 Fri</td>
<td><strong>Deadline for final-term seniors</strong> to submit HASS Concentration Completion form. $40 Late Fee.</td>
<td></td>
</tr>
<tr>
<td>5 Fri</td>
<td>Final deadline for all juniors to submit HASS Concentration Proposal form.</td>
<td></td>
</tr>
<tr>
<td>8 Mon</td>
<td>Term Summaries of grades for IAP delivered to departments.</td>
<td></td>
</tr>
<tr>
<td>8 Mon</td>
<td>Third-quarter Physical Education classes begin.</td>
<td></td>
</tr>
<tr>
<td>9 Tue</td>
<td>2 pm Graduate Academic Performance Meeting.</td>
<td></td>
</tr>
<tr>
<td>12 Fri</td>
<td>1 pm CAP February Degree Candidates Meeting.</td>
<td></td>
</tr>
<tr>
<td>15 Mon</td>
<td>Presidents Day—Holiday.</td>
<td></td>
</tr>
<tr>
<td>16 Tue</td>
<td><strong>Monday schedule of classes to be held</strong>.</td>
<td></td>
</tr>
<tr>
<td>17 Wed</td>
<td>Faculty Officers recommend degrees to Corporation.</td>
<td></td>
</tr>
<tr>
<td>19 Fri</td>
<td><strong>Minor completion date.</strong> Deadline for submission of Minor Completion form for final-term seniors. $40 Late Fee.</td>
<td></td>
</tr>
<tr>
<td>26 Fri</td>
<td>Last day to sign up for family health insurance or waive individual coverage, E23-308.</td>
<td></td>
</tr>
<tr>
<td>5 Fri</td>
<td><strong>Add date.</strong> Last day to add subjects to Registration.</td>
<td></td>
</tr>
<tr>
<td>5 Fri</td>
<td>Last day for juniors/seniors to change an elective to or from P/D/F grading.</td>
<td></td>
</tr>
<tr>
<td>5 Fri</td>
<td>Last day for graduate students to change a subject to or from P/D/F grading.</td>
<td></td>
</tr>
<tr>
<td>5 Fri</td>
<td>Last day to change a subject from Listener to Credit.</td>
<td></td>
</tr>
<tr>
<td>5 Fri</td>
<td>Late fee ($100) and petition required for students completing registration after this date.</td>
<td></td>
</tr>
<tr>
<td>5 Fri</td>
<td>Last day to petition for second SB for February 2011 degree candidates.</td>
<td></td>
</tr>
<tr>
<td>5 Fri</td>
<td>Last day for February 2011 degree candidates to apply for a double major.</td>
<td></td>
</tr>
<tr>
<td>5 Fri</td>
<td>Last day to drop half-term subjects offered in first half of term.</td>
<td></td>
</tr>
<tr>
<td>5 Fri</td>
<td>Deadline for completing cross-registration. $40 Late Fee for petitions approved after this date.</td>
<td></td>
</tr>
<tr>
<td>5 Fri</td>
<td>Spring Vacation.</td>
<td></td>
</tr>
<tr>
<td>22–26 Mon–Fri</td>
<td><strong>Drop date.</strong> Last day to cancel subjects from Registration.</td>
<td></td>
</tr>
<tr>
<td>22–26 Mon–Fri</td>
<td>Last day to add time-arranged subject that started after beginning of the term.</td>
<td></td>
</tr>
<tr>
<td>22–26 Mon–Fri</td>
<td>Last day to petition for May Advanced Standing Exam (given during Final Exam Period).</td>
<td></td>
</tr>
<tr>
<td>22–26 Mon–Fri</td>
<td>Last day to add half-term subjects offered in second half of term.</td>
<td></td>
</tr>
<tr>
<td>30 Fri</td>
<td><strong>Thesis Due</strong> for doctoral degrees.</td>
<td></td>
</tr>
</tbody>
</table>
ONLINE PREREGISTRATION for Fall Term and Summer Session 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 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 in the subject.

THESIS DUE for degrees other than doctoral

LAST DAY OF CLASSES

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

FINAL EXAM WEEK

GRADE DEADLINE. Grades due in Registrar's Office, 5-119, according to due date indicated on the Grade Sheet. Grade Sheets must be signed, enclosed in envelopes, sealed, and delivered to Registrar's Office on or before due date.

LAST DAY TO GO OFF THE JUNE DEGREE LIST

8 am Term Summaries of Spring Term grades delivered to departments

DEPARTMENT GRADUATES MEETINGS

10 am Fourth-Year Grades Meeting
1 pm Graduate Academic Performance Meeting
Faculty Officers recommend degrees to Corporation

SUMMER SESSION PREREGISTRATION DEADLINE. Deadline for all students to preregister online for Summer Session. $40 Late Fee.

FALL PREREGISTRATION DEADLINE. Continuing students must initiate online preregistration by this date. $40 Late Fee ($75 after August 20).

Memorial Day—Holiday

Key dates for Academic Year 2010–2011

2010 2011

Sep 6 3 Mon Independent Activities Period begins
7 Tue Labor Day
Oct 11 19 Mon Columbus Day—Holiday
Nov 11 21 Mon Veterans Day—Holiday
25–26 Thu–Fri Thanksgiving Vacation
Dec 9 17 Mon Martin Luther King, Jr. Day—Holiday
18 Sat Last day of classes (Final Exams, Mon–Fri, December 13–17)
Jan 3 21 Mon Presidents Day—Holiday
7 Tue Registration Day—Fall Term; classes begin Wednesday
17 Mon Martin Luther King, Jr. Day—Holiday
18 Tue Monday schedule of classes
28 Fri Independent Activities Period ends
Mar 21–25 Mon–Fri Spring Vacation
Apr 18–19 Mon–Tue Patriots Day—Holiday
May 12 Thu Last day of classes (Final Exams, Mon–Fri, May 16–20)
Jun 3 Fri Commencement

Key dates for Academic Year 2010–2011

2010 2011

May

3 Fri

13 Thu

17–21 Mon–Fri

18–25 Tue–Wed

21 Fri

27 Thu

28 Fri

31 Mon Memorial Day—Holiday

June

1 Tue

2 Wed

3 Thu

4 Fri

7 Mon

15 Tue

16 Wed

2010

Sep 6  Mon Labor Day
7  Tue Registration Day—Fall Term; classes begin Wednesday
Oct 11  Mon Columbus Day—Holiday
Nov 11  Thu Veterans Day—Holiday
25–26 Thu–Fri Thanksgiving Vacation
Dec 9  Thu Last day of classes (Final Exams, Mon–Fri, December 13–17)
18  Sat Winter Vacation begins (ends Sun, Jan 2)

2011

Jan 3  Mon Independent Activities Period begins
17  Mon Martin Luther King, Jr. Day—Holiday
21  Mon Presidents Day—Holiday
28  Fri Independent Activities Period ends
31  Mon Registration Day—Spring Term; classes begin Tuesday
Feb 21  Mon Presidents Day—Holiday
22  Tue Monday schedule of classes
Mar 21–25  Mon–Fri Spring Vacation
Apr 18–19  Mon–Tue Patriots Day—Holiday
May 12  Thu Last day of classes (Final Exams, Mon–Fri, May 16–20)
Jun 3  Fri Commencement
Part 1

This Is MIT
Here’s a quick look at what makes MIT tick—the ingredients of a world-class educational institution.

<table>
<thead>
<tr>
<th>Overview</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Around Campus</td>
<td>13</td>
</tr>
<tr>
<td>Academic Program</td>
<td>16</td>
</tr>
<tr>
<td>Administration</td>
<td>18</td>
</tr>
<tr>
<td>Alumni</td>
<td>18</td>
</tr>
</tbody>
</table>
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.

As recommended by the Task Force, 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. Upon completion, this initiative will have 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 ongoing transformation of the Vassar Streetscape, turning a nondescript urban byway into a central campus boulevard unifying the physical and aesthetic connections among MIT’s buildings and public spaces.

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 10,299 students in 2008–2009, including 4,153 undergraduates and 6,146 graduate students. These MIT students came from all 50 states, the District of Columbia, four territories, and 115 foreign countries. Ten percent of the undergraduates and 42 percent of the graduate students were international.

In the same year, there were 1,009 faculty members in MIT’s professorial ranks, including 598 women. The total teaching staff numbered 1,725. 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 are the Alfred P. Sloan Building and the Grover M. Hermann Building, which house activities in management, economics, international studies, and political science. Adjacent to them is Eastgate, a 29-story student family apartment tower. The building at 70 Memorial Drive, along the riverfront, currently contains classrooms and office space for the MIT Sloan School of Management; the Program in Science, Technology, and Society; and the School of Humanities, Arts, and Social Sciences. Now under construction is a 215,000-square-foot building that is scheduled to open in the fall of 2010. As the new home of the MIT Sloan School of Management, this building will create a new eastern gateway to the campus from Main Street.

Also located on the east end of the campus are buildings housing the Whitaker College of Health Sciences and Technology and MIT Medical’s Health Services Center. The Whitaker College building includes research laboratories, classrooms, and the college headquarters. The Health Services Center provides a pharmacy, infirmary, and facilities for medical, dental, surgical, and other specialties.

Adjacent to Whitaker College 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. Scheduled to open in late fall 2009 is a 163,000-square-foot extension to the building. Designed by a team headed by Pritzker Prize–winning architect Fumihiko Maki and executive architects Leers Weinzapfel Associates, it will nearly double the size of the facility. The new building will link to the Wiesner Building through a multi-tiered central atrium flanked by nine fully visible laboratories.

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.
A major feature of MIT's physical environment is the Pierce Boathouse and the Walter C. Wood Sailing Pavilion, which provide centers for extensive activity in crew and in sailing.

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 fiftieth 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.

Simmons Hall

The shimmering exterior of Simmons Hall is wrapped in windows 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.

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.

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 neighborhoods, ranging from approximately 700 to 15,000 residents. Only five cities in the United States with a population 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 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 Banknorth 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
OVERVIEW

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. This event will be visible November 11–13, 2009, starting at 4:19 pm, and January 27–30, 2010, starting at 4:47 pm. 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/.

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, divisions, and programs 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

School of Humanities, Arts, and Social Sciences
- Anthropology
- Comparative Media Studies
- Economics
- Foreign Languages and Literatures
- History
- Humanities
- Linguistics and Philosophy
The undergraduate academic program is based on a core of General Institute Requirements and on the specific curricula offered by departments for undergraduate majors. Undergraduate courses at MIT all 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), Metallurgical Engineer (MetE), 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 for Institute Affairs 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
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.
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, 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 the five schools and Whitaker College. 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 regularly 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 the online organization chart at http://web.mit.edu/ogchart/.

ALUMNI

MIT Alumni Association
The MIT Alumni Association, founded by alumni in 1875, provides ways for the Institute’s 120,746 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. More than 9,700 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 MIT On the Road, Tech Reunions, and the Enterprise Forum of MIT.

In fiscal year 2008, the Alumni Fund reported $48.8 million in gifts, contributed by more than 36,652 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.

### Campus Life

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities</td>
<td>20</td>
</tr>
<tr>
<td>Advising and Counseling</td>
<td>20</td>
</tr>
<tr>
<td>Arts at MIT</td>
<td>20</td>
</tr>
<tr>
<td>Athletics</td>
<td>22</td>
</tr>
<tr>
<td>Campus Dining</td>
<td>23</td>
</tr>
<tr>
<td>Campus Media</td>
<td>23</td>
</tr>
<tr>
<td>Campus Parking</td>
<td>23</td>
</tr>
<tr>
<td>Child Care and Parenting Resources</td>
<td>24</td>
</tr>
<tr>
<td>Disabilities Services Office</td>
<td>24</td>
</tr>
<tr>
<td>Fraternities, Sororities, and Independent Living Groups</td>
<td>24</td>
</tr>
<tr>
<td>Housing</td>
<td>25</td>
</tr>
<tr>
<td>Information Services and Technology</td>
<td>26</td>
</tr>
<tr>
<td>Libraries</td>
<td>27</td>
</tr>
<tr>
<td>Medical Services</td>
<td>27</td>
</tr>
<tr>
<td>MIT OpenCourseWare</td>
<td>27</td>
</tr>
<tr>
<td>Public Service Center</td>
<td>28</td>
</tr>
<tr>
<td>Religious Organizations</td>
<td>28</td>
</tr>
<tr>
<td>Student Government</td>
<td>28</td>
</tr>
<tr>
<td>Student Services Center</td>
<td>29</td>
</tr>
<tr>
<td>WebSIS</td>
<td>29</td>
</tr>
</tbody>
</table>
ACTIVITIES

There is much more to an MIT education than 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. This section describes just a few of the activities that define campus life.

There are more than 300 co-curricular clubs and activities 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 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 groups oriented toward different backgrounds and lifestyles. 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 or see the ASA website at http://web.mit.edu/asa/www/, or contact the Student Activities Office, Room W20-549, 617-253-6777.

ADVISING AND COUNSELING

The Institute offers a variety of resources for advising, counseling, and personal support. By intention, they are not centralized in one counseling center. 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. The Student Support Services section of the Office of the Dean for Student Life offers counseling and advising to all students, whether the situation is academic or personal or both. It also provides a broad range of assistance to all students and has special responsibilities for supporting students who are women, members of underrepresented minorities, or lesbian, gay, bisexual, or transgendered. In addition, students are frequently able to get the help they need from a fellow student or from an instructor who is not officially a faculty advisor. Coaches and activity advisors can be helpful as well.

Several campus offices specialize in particular areas, such as Student Financial Services (including student employment), the religious counselors, the Global Education and Career Development Center, and the Office of Undergraduate Advising and Academic Programs. The Campus Police can be helpful to students in many ways, and for students seeking information about particular fields, there is a Premedical Advisory Council, and a Prelaw Advisory Council.

The psychiatrists, psychologists, and social workers in the Medical Department are considered by many students to be the Institute’s most skilled counselors. In addition, the Center for Health Promotion and Wellness runs seminars ranging from stress management and smoking cessation to weight control and nutrition education, and the department’s Social Work Service provides individual and group counseling for substance abusers.

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—winning composer John Harbison and writer Junot Díaz, as well as writer Alan Lightman, video and performance artist Joan Jonas, and conceptual artist Krzysztof Wodiczko.

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”, from Shakespearean plays to improv comedy, and from ballroom to modern dance. MIT’s world music program features Boston’s only Balinese gamelan, a Senegalese drumming ensemble, and an acclaimed South Asian performance series.

Dance

At MIT, students can now pursue a concentration in dance, also known as “Physical Imagination,” where students are exposed to movement composition and theory, history and literature, and performance. 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://web.mit.edu/arts/dance/.
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 Artist-in-Residence Program frequently present readings and lectures by renowned writers. For more information, call 617-253-7894 or visit http://web.mit.edu/humanistic/www/. 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, during IAP, meets each weekday, bringing together faculty, staff, students, and others from the community who share a love of poetry. It also sponsors readings by visiting authors who 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. Also see http://web.mit.edu/arts/literaryarts/.

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://www.media.mit.edu and http://web.mit.edu/arts/mediaarts/.

Music
MIT's music faculty includes internationally acclaimed composers, performers, and musicologists. Students can take private lessons with financial support from the Emerson scholarship 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 Galaktika, 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, MITHAS, and Thursday Noon Chapel series. 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://web.mit.edu/arts/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. 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://web.mit.edu/arts/theater/.

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). 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 the Cross-Registration Program (see http://web.mit.edu/arts/learn/visualoffcampus.html). Opportunities for on-campus coursework in the visual arts can be found by consulting the Visual Arts Program of the Department of Architecture, the Center for Advanced Visual Studies, and the Comparative Media Studies Program, or by visiting http://web.mit.edu/arts/visualarts/.

Artists-in-Residence
A flourishing Artist-in-Residence Program complements the curriculum, allowing students to engage with distinguished visiting artists, including novelist Margaret Atwood, poet and novelist Chris Abani, composer Tan Dun, cartoonist Art Spiegelman, video artist Bill Viola, visual artist Zanele Muholi, action architect Elizabeth Streb, filmmaker Michel Gondry, graffiti artists Tats Cru, and architect/engineer/artist Santiago Calatrava.

Arts Initiatives
Arts Initiatives works with the associate provost, Philip Khoury, on strategic planning, communications, development, and cross-school coordination in the arts.
Part 2: MIT Arts and Culture

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), the Media Test Wall in the Whitaker Building (Building 56), and the Dean’s Gallery in the Sloan School (Building E52). All are free and open to the public. Nationally distributed catalogs, gallery talks, symposia, and films accompany the exhibitions.

The List Center also manages MIT’s permanent collection of artworks, including a student loan art program that enables students to borrow original works 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, call 617-253-4680, or 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 which 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. Visit http://web.mit.edu/museum/ for an in-depth look at the museum’s collections, exhibitions, public programs, and services to the community.

Office of the Arts
The Office of the Arts oversees, coordinates, supports, and facilitates arts activities under the direction of the associate provost. The office’s branches include the Council for the Arts and Student and Artist-in-Residence Programs. For general information on arts programs and activities at MIT, call the office at 617-253-4003, or stop by Room E15-205. Also be sure to visit Arts at MIT at http://artscal.mit.edu/ and see the arts calendar at http://artscale.mit.edu/.

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. Appointed by the president of MIT to three-year terms, council members are major donors to the arts at MIT and serve as advisers to the associate provost. The Council for the Arts recognizes distinguished artists from all disciplines with one of the most lucrative prizes in the arts, the McDermott Award. 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://web.mit.edu/arts/about/office/council/index.html. Council programs directly benefit MIT students by providing free tickets to the Boston Symphony Orchestra, Boston Chamber Music Society, the Radius Ensemble, 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, 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://web.mit.edu/arts/do/funding/grantguide.html.

Student Programs
There are many programs helping students find community in the arts. Freshman seminars led by MIT faculty and staff encourage participants to discover the arts resources at MIT and in the Boston area and share their art experience with one another through an Arts Share and hands-on workshops. The Arts Scholars Program enables students who are active in the arts to meet and converse at dinners and excursions and opens opportunities for them to collaborate in workshops or on independent projects. The Art Rep Program is a network of students in each dorm, living group, and graduate department linking students to arts events at MIT through weekly communications. The Grad Arts Forum encourages interdisciplinary communication among graduate students in the arts through a series of forums centered on themes connecting their artwork. Promoting the Arts Through Design, a seminar, provides students with a hands-on opportunity to learn design through the completion of a project for a local nonprofit arts organization client. Student Programs also administers the annual mural competition for currently enrolled MIT students. For more information, visit http://web.mit.edu/spair/.

Student Art Association
The Student Art Association offers noncredit classes and facilities for many visual arts activities including ceramics, photography, painting, and drawing. For more information, call 617-253-7019, or 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 program.

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,
rifle, sailing, squash, track and field, water polo, fencing, and men’s volleyball all compete against Division I opponents.

MIT features one of the nation’s most expansive club programs, with over 800 participants and 30 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, synchronized swimming, and cycling.

The MIT intramural sports program offers competition in 23 sports, with participation of more than 10,000 students, staff, and faculty. Ultimate frisbee, soccer, and badminton are among the most competitive and popular activities.

MIT’s athletic facilities include the Howard W. Johnson Athletics Center (with an indoor track and ice rink), the du Pont Athletic Center, Alumni Swimming Pool, Wood Sailing Pavilion, and Pierce Boathouse. The 26-acre Briggs playing fields include the du Pont Tennis Courts, nine softball diamonds (two with lights), and a multipurpose synthetic surface. The J. B. Carr Tennis Center includes four indoor plexi-cushion courts. Rockwell Cage accommodates varsity and intramural basketball, volleyball, and badminton. Steinbrenner Stadium features a 400-meter all-weather track. The Zesiger Sports Fitness Center houses two swimming pools, a health fitness center, international squash courts, and a multipurpose gymnasium.

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 has over 30 locations across the campus: a broad portfolio of food service management companies, restaurateurs, convenience store operators, and vending specialists creates a range of diverse, convenient, healthy, and economical options.

MIT does not offer traditional meal plans. Meals are paid for with cash or by using one of the two available MIT debit accounts: Dining Dollars or TechCASH. A Dining Dollars debit account is restricted to meal purchases and can be used in all dining halls, restaurants, food courts, and cafés on campus. A TechCASH account can be used for all campus services, including food purchases. Most locations do not accept credit or debit cards. More information about Dining Dollars and TechCASH accounts can be found at http://web.mit.edu/mitcard/.

Students looking to reduce daily meal costs can enroll in the House Dining Membership program, which provides members with a 50 percent discount on dinner meals prepared in House Dining Rooms. House Dining locations include Ashdown House, Baker House, Simmons Hall, Next House, and McCormick Hall; students who live in one of these halls are automatically enrolled in the program. House Dining rooms, like all Campus Dining operations, are open to the entire MIT Community.

To view MIT Campus Dining menus, check hours of operation, or get more information about any MIT Campus Dining program or location, visit http://web.mit.edu/dining/.

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 are also available.

CAMPUS MEDIA

Student publications at MIT include The Tech, a student newspaper published twice weekly; Technique, the senior yearbook; The Thistle, published by the Alternative News Collective; Voo Doo, an occasional humor magazine; The Graduate Student News, a publication of the Graduate Student Council; Counterpoint, a joint MIT-Wellesley student publication; Rune, a journal of arts and letters; and E-merging, a transcultural literary journal. 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. Parking spaces are allocated to upperclass students as available in the Westgate lot through Residence Life and Student Life Programs, Room E19-429. Graduate student residents may obtain MIT approval through the Graduate Residential Life Office in Room E19-429. Students living off campus should contact the MIT Parking and Transportation Office, mitparking@mit.edu, for commuter parking permit approval. Students with disabilities who have parking requests should see the Medical Department, or the Disabilities Services Department, for approval.
Students who plan to bring motor vehicles to Cambridge should take careful note of the information regarding pertinent Massachusetts laws 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.


CHILD CARE AND PARENTING RESOURCES

Center for Work, Family, and Personal Life
The MIT Center for Work, Family, and Personal Life 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, babysitters, schools, 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. Individual consultations are available by appointment. The center offers a number of workshops, briefings, and discussion groups, and maintains databases and a lending library. The office is located in Room 16-151, 617-253-1592, worklife@mit.edu, http://hrweb.mit.edu/worklife/index.html.

Technology Children’s Centers
MIT’s child care network, Technology Children’s Centers (TCC), provides year-round educational care to children from two months of age through kindergarten entry (approximately six years of age). TCC includes three sites on campus, and a fourth site near Lincoln Laboratory in Lexington, MA, approximately 10 miles west of campus. TCC’s campus centers, located at Eastgate, Stata, and Westgate, serve approximately 130 children; TCC at Lincoln Laboratory (LINC) serves an additional 110 children.

TCC offers priority enrollment to members of the MIT community. Please be advised that there are long waiting lists for children in all age groups, and particularly for infants and toddlers. TCC is managed by the MIT Center for Work, Family, and Personal Life, in partnership with Bright Horizons/Family Solutions, a child care management company.

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

MIT Day Camp
The MIT Day Camp is operated by the Athletic Department on weekdays from 9 am to 3:40 pm from late June through mid-August for children ages 6 to 13 1/2. An early drop-off starting at 8 am is available, and an extended sitting service is available until 5:30 pm. The eight-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.

DISABILITIES SERVICES OFFICE

The Disabilities Services Office (DSO) 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. The DSO provides qualified students with disabilities equal access to all Institute programs and services. The goals of the DSO’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 programs.

These services include obtaining and reviewing disability-related documentation and determining the appropriate accommodations required; communicating with faculty (with the student’s permission); and developing plans for accommodations. Disabilities Services also provides or arranges, a variety of auxiliary services to the MIT community, such as coordination for sign language interpreters, document translation, text alternatives, and other academic accommodations. The Disabilities Services Office is located in Room 7-145. For further information, call 617-253-1674 or visit http://web.mit.edu/dso/www/.

FRATERNITIES, SORORITIES, AND INDEPENDENT LIVING GROUPS

MIT recognizes 38 fraternities, sororities, and independent living groups (FSILGs). Of these, 25 are nationally affiliated fraternities, two are local, and one is coed. There are also five living groups, four of which are coed and one is for women only. All six sororities are nationally affiliated; four are residential. Most groups live in houses owned by the respective chapter’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 represents the sororities, and the Living Group Council represents the living groups.

In addition, there are several students affiliated with historically black and Latino fraternities and sororities at MIT.

The oldest fraternity on campus was founded at MIT in 1873. More than 45 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.

Each fraternity, sorority, and living group espouses the values of 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 fraternity, sorority, or living group has a live-in resident advisor (usually an MIT graduate student). Resident advisors serve as mentors, guides, and resources for students and act as a liaison between the undergraduate chapter 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 hold recruitment events year round. In addition, incoming students receive information about the FSILGs through summer mailings of brochures and booklets. For more information about FSILGs, contact the Fraternity, Sorority, and Living Group Office in the Stratton Student Center, Room W20-549, 617-253-7546, or FSILG-Office@mit.edu.

**Housing**

**Undergraduate Single Student**

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 1,000 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. The 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 with the approval of the assistant director for undergraduate housing.

**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
- Stanley McCormick Hall
- New West Campus Houses—Ballard, Lawrence, Coolidge, Desmond, Fisk, and Thorn, which include Chocolate City, French House, German House, International House, and Spanish House
- 500 Memorial Drive (Next House)
- Phoenix Group (NW35)
- Random Hall
- Senior House
- Simmons Hall

Rooms in the Institute houses are engaged for the full academic year. For 2009–2010 the rents for the houses will range from $2,650 to $3,801 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.

**Student House**

The MIT Student House is a coeducational, cooperative living group for financially needy students. It is owned by a corporation of Student House alumni and alumnae and is located off campus in Boston. The 30 undergraduate members maintain the residence and do all the work except for major repairs. Students cooperate in the management of the house and the academic, recreational, and social aspects of student life, thereby creating a savings per member averaging $1,000 per semester. Student House is also a member of the Living Group Council. Information on Student House may be obtained by writing to studs-request@mit.edu, or MIT Student House, 111 Bay State Road, Boston, MA 02215-1798.

**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 W59-201, 617-253-2811. Information about fraternities or sororities also may be obtained...
### 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 $710 to $1,478 per month, per student. Details about each of the residences can be found at [http://web.mit.edu/housing/grad/residences.html](http://web.mit.edu/housing/grad/residences.html).

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. Apartments that become available outside the 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 $1,075 to $1,591 per month, per apartment. Details about each of the residences can be found at [http://web.mit.edu/housing/grad/residences.html](http://web.mit.edu/housing/grad/residences.html).

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://web.mit.edu/housing/grad/](http://web.mit.edu/housing/grad/).

The Graduate and Family Housing Office, located in W59-200, can be reached at [graduatehousing@mit.edu](mailto: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://web.mit.edu/housing/och/](http://web.mit.edu/housing/och/).

### Information Services and Technology

MIT’s computing environment gives community members access to a full range of information technologies and resources. The Information Services and Technology (IS&T) department supports “universal” services for everyone, such as telephones and network connections, including wireless, as well as services for specific constituencies, such as academic and administrative computing.
MITnet connects thousands of computers across the campus, and its connection to the internet gives MIT high-speed access to computers around the world. Wireless and wired access to MITnet is available across the entire campus, including all dorms.

The Athena Computing Environment, MIT’s campus-wide networked system of workstations, is available in computer labs, academic facilities, and QuickStations in academic buildings, libraries, and dorms. Athena is complemented by Macintosh and Windows labs providing additional resources. Across these environments students have access to courseware, electronic mail, mathematics and statistics packages, graphics and multimedia applications, engineering and programming tools, productivity software, printers, and other resources.

IS&T also provides computer buying advice and needs analysis, with a hands-on showroom of computer equipment recommended for use at MIT, including laptops recommended for students. Through MIT’s partnerships with web-based vendors, MIT students, faculty, and staff can purchase hardware, software, and accessories at educational discounts.

Technical support is provided through telephone and email help lines, consulting, training, and publications. 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://web.mit.edu/ist/.

**LIBRARIES**

The MIT Libraries support all of the Institute’s programs of research and study with holdings of more than 2.9 million print volumes and 3.1 million additional items, such as microforms, maps, images, musical scores, manuscripts, recordings, and electronic resources. The library system also includes the Institute Archives and Special Collections containing many of MIT’s founding documents, technical reports, and the personal papers of noted faculty. For a complete list of library locations and hours, see http://libraries.mit.edu/about/.

A wide range of online services and resources are available through the MIT Libraries’ website, at http://libraries.mit.edu/. Patrons can locate library items using the online catalog, Barton, at http://libraries.mit.edu/barton/, or search over 20,000 journals, databases, and other serial publications using Vera, at http://libraries.mit.edu/vera/.

In addition, the online interlibrary loan service, at http://libraries.mit.edu/illiad/, makes available materials from other libraries worldwide. On-site access is provided to 18 local libraries in the Boston Library Consortium.

Other library resources and services include: Academic Media Production Services for video production and conferencing, webcasting, and distance education; complete digital scanning, microfilm, and photocopying facilities; GIS and data resources; and metadata services.

Workshops on library resources and instructional support are offered for MIT courses and other groups, and in-depth consultation on research projects is available with subject specialists. Reference assistance is also available through the Ask Us! service, at http://libraries.mit.edu/ask/, and from library staff.

The MIT Libraries also manage DSpace (http://dspace.mit.edu/), a unique digital repository created to capture, preserve, and share MIT’s intellectual output with the world. DSpace currently houses over 20,000 MIT theses and the digital works of 50 communities representing collections of MIT faculty, researchers, labs, and centers.

While primarily serving the MIT community, library facilities at MIT can be used by others upon application to Document Services, Room 14-0551, for a library privilege card.

**MEDICAL SERVICES**

**MIT Medical**

To meet the health care needs of MIT community members, MIT Medical offers a single, centralized source of comprehensive health insurance, care and treatment at its own medical centers, and an extensive roster of health promotion programs. Convenient, on-campus access to a broad range of clinical services and medical and dental specialties is delivered by highly qualified health care professionals. Affiliations with many of the Boston area’s leading hospitals allow clinicians to refer patients with more serious conditions to the most appropriate specialists.

Visits to MIT Medical are by appointment, except for urgent care, which is available 24 hours a day. The Mental Health Service also has walk-in urgent care hours from 2 to 4 daily, Monday through Friday. MIT community members should call 617-253-1311 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.

**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 January 2009, the initiative includes materials from more than 1,880 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 3 million individuals to date. Visitors have come to the site from more than 253 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 200 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@mit.edu.

PUBLIC SERVICE CENTER

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

Through a selection of fellowships and grants, the IDEAS Competition, programs such as ScienceExpo and Freshmen Urban Program (FUP), community service work-study positions, service learning classes, advising resources, and the International House for Global Leadership (iHouse, a residential living-learning environment), PSC helps students with hands-on experiences that serve communities and the students themselves in life-transforming ways.

**Fellowships, Value-Added Internships, and Grants.** In locations as near as Cambridge or as far as India, there are many opportunities to work on community issues, whether it is addressing predatory lending in the city of Lawrence, MA; implementing a reforestation and tree nursery plan in Mexico; or testing an electronic pill box in India. Students can work individually or as part of a team on projects during term breaks and during the academic year.

**The MIT IDEAS Competition.** Students form teams to develop and implement projects that make a positive change for communities across the globe. Entries are judged on their innovation, feasibility, and community impact.

**Programs, Planning, and Volunteering.** Through local outreach programs, MIT students can teach in a K-12 science classroom, serve as a mentor to adolescents in math and science, or teach a child to read.

**CityDays, ScienceExpo, FUP, Giving Tree, and ReachOut are programs led by students under the direction of the PSC.** PSC staff also 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.

**Service Learning.** Applied learning for student and community benefit is another way that students can gain pragmatic educational and life experiences while serving community needs. For example, freshmen can enroll in a public service design seminar, where they may build a prototype that eases vaccine transportation in the developing world, or redesign a community garden’s composting device. Students can gain a deeper understanding of their subjects, and a better understanding of their own problem-solving capabilities.

**iHouse.** A newly formed living-learning community, iHouse is focused on MIT’s mission of applied learning and global leadership development.

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/](http://web.mit.edu/outreach/). The PSC website, [http://web.mit.edu/mitpsc/](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.

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 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 Graduate Student 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.

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 publishes Graduate Student News and maintains a comprehensive website at http://gsc.mit.edu/ which serves as a repository for a large amount of information relevant to graduate students.

WebSIS
WebSIS is a self-service website for students, faculty, and staff. Through WebSIS students can view their academic, financial, and biographic records, preregister for upcoming terms, check grades, maintain address information, and apply for their degrees; advisors and administrators can view the academic records of students in their departments and approve degree applicants; instructors and administrators can view enrollment lists, student photographs, and prerequisite reports for their classes.

For more information visit http://student.mit.edu/.

Student Services Center
The Student Services Center, conveniently located along the Infinite Corridor in Room 11-120, provides students with information about their financial and academic records in one central location together with services such as registration, transcripts, enrollment certification, cross-registra-

loans, payment plans, 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 ssc-www@mit.edu. Visit http://web.mit.edu/sfs/about_us/ for a complete description of the financial services available to students.
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.

<table>
<thead>
<tr>
<th>Academic Programs</th>
<th>31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman Year</td>
<td>31</td>
</tr>
<tr>
<td>Major Course of Study</td>
<td>34</td>
</tr>
<tr>
<td>Minors</td>
<td>34</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>General Institute Requirements</th>
<th>36</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>36</td>
</tr>
<tr>
<td>Communication Requirement</td>
<td>37</td>
</tr>
<tr>
<td>HASS Requirement</td>
<td>38</td>
</tr>
<tr>
<td>REST Requirement</td>
<td>40</td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>41</td>
</tr>
<tr>
<td>Physical Education Requirement</td>
<td>42</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Academic and Research Options</th>
<th>43</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent Activities Period</td>
<td>43</td>
</tr>
<tr>
<td>Undergraduate Research Opportunities Program</td>
<td>43</td>
</tr>
<tr>
<td>Undergraduate Seminars and Freshman Advising Seminars</td>
<td>44</td>
</tr>
<tr>
<td>Edgerton Center</td>
<td>44</td>
</tr>
<tr>
<td>Grading Options</td>
<td>44</td>
</tr>
<tr>
<td>Study at Other Universities</td>
<td>45</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Career and Professional Options</th>
<th>47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Education and Career Development Center</td>
<td>47</td>
</tr>
<tr>
<td>Teacher Training and Education</td>
<td>48</td>
</tr>
<tr>
<td>ROTC Programs</td>
<td>48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Admissions</th>
<th>51</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs</td>
<td>53</td>
</tr>
<tr>
<td>Financial Aid</td>
<td>55</td>
</tr>
<tr>
<td>Medical Requirements</td>
<td>56</td>
</tr>
</tbody>
</table>
**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 1998 and 2002, 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), including but not limited to designated HASS-Distribution Requirement 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), other undergraduate seminars, or project-based subjects. 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**

A student who chooses the Concourse Program becomes a member of a group of about 60 freshmen working with a team of faculty members in a yearlong program of study which covers most of the first-year General Institute Requirements. In structure and atmosphere, Concourse resembles a small school rather than a large institution. Concourse has operated as a special program for freshmen since 1971 and is a regular part of the MIT curriculum, operating under the aegis of the Office of the Dean for Undergraduate Education. Because of the greater level of personal attention and socialization, it is possible to connect and unify the separate subjects and also to encourage students to help, communicate with, and support one another. The approach is that of a scholarly community, with intense participation and support by faculty, staff, student assistants, and freshmen. Subjects can be approached with greater rigor but the experience can be more enjoyable, and very successful experiments such as “From Russia With Love: The Thirty Year Problem Set” become possible.
Concourse faculty, representing different professional disciplines, collaborate closely in the planning and teaching of the curriculum. Regularly scheduled class sessions, which all meet in a single Concourse Classroom or in the Concourse Lounge, are supplemented by many less formal activities, e.g., “breakfast with your chemistry teacher.” A student may carry at least one subject per term outside the Concourse Program. Subject matter is arranged so that the student receives credit for the first-year General Institute Requirements on successful completion of the program. In addition, special courses are offered. Besides promoting close and sustained contact between students and faculty, the scheduling of the program enhances participation in advisor seminars and extracurricular activities.

The program’s director is Bernhardt L. Trout. For more information, contact Cheryl Butters, Room 16-135, 617-253-3200. A detailed description of the program may be found online at http://web.mit.edu/concourse/.

**Experimental Study Group**

The Experimental Study Group (ESG) is an innovative academic program geared primarily toward motivated first-year students who wish to take an active part in their MIT education. Each year 50 freshmen, 12 staff members, and 26 upperclass instructors (who were in ESG as freshmen) participate in the program. Staff members are selected for their teaching ability and their 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 10 students), discussion-based seminars, study groups, and hands-on labs. Almost all the core subjects in biology, chemistry, mathematics, physics, and politics are offered through ESG, in addition to several humanities, arts, and social science subjects (typically in the areas of writing or philosophy). Although ESG can be a full-time activity for freshmen, students may take one or two subjects outside of ESG.

ESG’s small classes are structured as 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 American Photography, Psychology of Terror and Hope, Mathematics of Toys and Games, and Exploring Pharmacology.

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 freshmen such as hiking and skiing trips and visits to local museums and attractions.

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 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 8.02 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.)

The program director is Dr. V. Michael Bove, Jr. For information contact Linda Peterson, Room E15-401, mas@media.mit.edu, or visit http://www.media.mit.edu/mas/fyo/.

**Terrascope**

The Terrascope Program offers a unique opportunity for MIT freshmen to expand their academic experience beyond the walls of the classroom. Terrascope balances the lecture/problem set learning of introductory (or “core”) science subjects with studies of complex, real-world problems that require innovative solutions drawn from a variety of disciplines.

The program is based on the idea that our Earth system provides a valuable context for learning basic science and engineering concepts. Students are encouraged to apply those concepts in creative ways to understand the interdependent physical, chemical, and biological processes that shape our planet, and to design strategies to ensure a sustainable environment for the future.

Terrascope is a flexible program—only two subjects are required beyond the traditional General Institute Requirements (GIRs). During the fall term, Terrascope students enroll in 12.000 Solving Complex Problems (9 units), a popular subject (also known as Mission 2012) designed to explore how teams of scientists and engineers approach difficult problems that require multidisciplinary approaches. Solutions will be published on a class website and participants will defend their work before a panel of outside experts. This final presentation will be broadcast live over the internet.
In the spring, students enroll in 1.016 Communicating Complex Environmental Issues: Designing and Building Interactive Museum Exhibits (9 units). Using 12,000 as a starting point, students will work in teams to design, engineer, and build an interactive museum-style exhibit that teaches others about some aspect of the problem on which they've become expert.

Students may also choose to enroll in SP.360 Terrascope Radio (12 units), an optional subject that provides an opportunity to satisfy the freshman Communication Requirement (CI-H credit). This subject explores radio as a medium for expression and communication, particularly of complex scientific ideas, and culminates in the production of a professional-quality radio program.

Fieldwork and close interactions with researchers and others is an important part of the Terrascope experience. Terrascope students attend weekly lunch seminars during which researchers and others speak about their work. Students may also participate in a credit-bearing activity during MIT’s Independent Activities Period. Finally, students in the Terrascope program have the opportunity to conduct field research in a location relevant to the problem under study during spring break. Past locations have included Alaska, the Amazon rainforest, Chile, the Galapagos Islands, Iceland, and New Orleans. Expenses for the trip are largely covered by the program.

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

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

**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. A facilitator guides each working group, where the facilitator 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 can 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 can 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 4-113, 617-253-5010, or visit http://web.mit.edu/ome/.

**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**

Subjects taken by freshmen in the first term and IAP are graded on a pass or no-record basis. In the first term and IAP freshmen 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). Students who receive Ds or Fs earn no credit in those subjects, and these grades do not appear on their external records.

In the second term freshmen are graded A, B, C, or no record. They will receive A, B, or C grades that appear on their external records but continue to earn no credit for Ds and Fs, which do not appear on their external records. Second-term passing 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. In almost all circumstances, hidden grades will stay hidden and are not included on an external transcript. However, students should be aware that some medical schools and some Federal grant programs (currently ACG/SMART grants) require a GPA to be calculated using all grades that are available to the student, including hidden grades. Under these specific circumstances, the hidden grades can be released by MIT only with the explicit written permission of a student.

Many students use the freedom of hidden grades in the first year to adjust to the demands of MIT and to take some educational risks. Students planning to apply to medical school or receiving certain Federal grants should reflect carefully on their choices in light of the fact that the actual grades will be taken into account for medical school admission or eligibility for the Federal grants. Students in these positions should discuss their options with their adviser and carefully weigh their choices.

**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: You Can Be A Success at MIT.)

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 (IAP) 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 can be used for several different purposes. For example, students who are undecided about their eventual majors can use some part of their elective time to get more information about the various departments or fields they are considering. Students more certain of their professional goals can use electives to explore areas of secondary interest. Still other students will choose to begin work on departmental or General Institute Requirements, deferring subjects of a more supplemental nature until a later year. The study of a language also may be started or continued.

Freshmen should select electives that best suit their individual needs. There are several hundred subjects without prerequisites that students can select during the freshman year. However, any subject offered by the Institute is open to all students, provided they satisfy the prerequisites.

Double Majors

Students who plan to graduate in 2010 or later 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.

Students who have successfully petitioned to pursue a second bachelor’s degree may switch to a double major in the same field through Add Date of their final term. Students who want to switch from a second SB to a double major and also plan to change departments in one or both majors must apply for a double major by Add Date of their penultimate term.

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

Program for Two Bachelor’s Degrees

This program is being discontinued and is not available to students who began their studies during the 2008–2009 academic year or later.

A student who is eligible to pursue a second SB must satisfy the requirements of the second department and complete 90 credit units in addition to the requirements for the first degree. This means that in the combined program, the student must complete at least 270 units beyond the 17-subject General Institute Requirements (GIRs). An eligible student must submit a petition to the Committee on Curricula (COC) by Add Date of the term prior to the term in which the student intends to receive the first of the two degrees. Petitions submitted after this deadline will be considered by the COC at its discretion on a case-by-case basis.

Students who have successfully petitioned to pursue a second SB may switch to a double major in the same fields through Add Date of their final term. Students who want to switch from a second SB to a double major and also plan to change departments in one or both majors must apply for a double major by Add Date of their penultimate term.

For details on eligibility, deadlines, and procedures, see the COC website, http://web.mit.edu/registrar/subjects/cmtes/coc/petitions_secondSB.html.

Minors

A number of fields in science, engineering, architecture, and the humanities, arts, and social sciences offer minor programs providing significant experience in their disciplines. Several interdisciplinary minors, including a new Institute-wide minor in energy studies, are also available; for
Students who successfully complete minor programs will have their fields of study specified as part of their Bachelor of Science degrees, thus giving public recognition of focused work in other disciplines. The general guidelines for a minor program are as follows:

- Minor programs consist of five to seven subjects, though generally six. These subjects may count toward General Institute Requirements and Departmental Program requirements.
- 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, 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 not take a minor in the area of his or her major. In addition, minors are not allowed in either field of composite degrees, which combine two different fields (for example, the SB in Mathematics with Computer Science, SB in Humanities and Science, or the SB in Humanities and Engineering).
- 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 two SB degrees.
- The student should designate the minor program 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 the application and completion forms for HASS minors are different from those used in other fields.

**Minor in Humanities, Arts, or Social Sciences**

Students electing a Humanities, Arts, and Social Sciences (HASS) minor program will study a field in greater depth than the HASS concentration component of the General Institute Requirements allows and will encounter the structure of an intellectual discipline to a greater degree.

Most HASS minor programs are arranged into at least three levels, or tiers, expressing different degrees of sophistication in the articulation and resolution of intellectual problems. However, subjects included in the regional studies minors are divided into four areas; students are required to distribute subjects across those four areas.

**Minor in an Architecture, Engineering, Management, or Science Field**

Minors are currently available in the following architecture, engineering, management, and science fields:

- Architecture
- Astronomy*
- Biology
- Biomedical Engineering*
- Brain and Cognitive Sciences
- Chemistry
- Civil Engineering
- Earth, Atmospheric, and Planetary Sciences
- Energy Studies*
- Environmental Engineering Science
- Management
- Management Science
- Materials Science and Engineering
- Mathematics
- Mechanical Engineering
- Nuclear Science and Engineering
- Physics
- Toxicology and Environmental Health

More information on these minors appears in Part 2 of this catalog; those marked with an asterisk are described in the Interdisciplinary Undergraduate Programs and Minors section in Part 3. 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.

**Minor in an Architecture, Engineering, Management, or Science Field**

Minors are currently available in the following architecture, engineering, management, and science fields:

- Architecture
- Astronomy*
- Biology
- Biomedical Engineering*
- Brain and Cognitive Sciences
- Chemistry
- Civil Engineering
- Earth, Atmospheric, and Planetary Sciences
- Energy Studies*
- Environmental Engineering Science
- Management
- Management Science
- Materials Science and Engineering
- Mathematics
- Mechanical Engineering
- Nuclear Science and Engineering
- Physics
- Toxicology and Environmental Health

More information on these minors appears in Part 2 of this catalog; those marked with an asterisk are described in the Interdisciplinary Undergraduate Programs and Minors section in Part 3. 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.
Detailed information on these minors may be found in Part 2 of this catalog; those marked with an asterisk are described in the Interdisciplinary Undergraduate Programs and Minors section in Part 3. Additional information about the HASS minors also is available at the Humanities, Arts, and Social Sciences Education Office (Room 14N-410) or at http://shass.mit.edu/undergraduate/.

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 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 for any substitutions in the Communication Requirement and the Committee on Curricula for any substitutions in other General Institute Requirements. 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 Science, 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.

Bachelor of Science Degree Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement:</td>
<td>6</td>
</tr>
<tr>
<td>Chemistry (5.101, 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)</td>
<td></td>
</tr>
<tr>
<td>Calculus (18.01, 18.01A, or 18.014; and 18.02, 18.02A, 18.022, 18.023, or 18.024)</td>
<td></td>
</tr>
<tr>
<td>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</td>
<td>8</td>
</tr>
<tr>
<td>includes 2 Communication Requirement subjects (CI-H)</td>
<td></td>
</tr>
<tr>
<td>Total GIR Subjects Required for SB Degree</td>
<td>17</td>
</tr>
<tr>
<td>Communication Requirement, to be satisfied by 4 subjects:</td>
<td></td>
</tr>
<tr>
<td>2 Communication-Intensive HASS subjects (CI-H)</td>
<td></td>
</tr>
<tr>
<td>2 Communication-Intensive Major subjects (CI-M)*</td>
<td></td>
</tr>
<tr>
<td>Physical Education Requirement</td>
<td></td>
</tr>
<tr>
<td>PLUS Departmental Program and Unrestricted Electives</td>
<td></td>
</tr>
<tr>
<td>The departmental program may specify some of the GIR subjects, and includes 180–198 additional units beyond the GIRs.</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>Notes</td>
<td></td>
</tr>
<tr>
<td>Transfer students generally will graduate under the requirements that apply to the class they join when they enter MIT.</td>
<td></td>
</tr>
<tr>
<td>¹ Communication-Intensive Major subjects (CI-M) are designated on the degree charts in Part 2.</td>
<td></td>
</tr>
<tr>
<td>² The total of 180–198 units does not include ROTC subjects, if elected.</td>
<td></td>
</tr>
</tbody>
</table>
Chemistry

The Institute requirement in chemistry can 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 present an introduction to chemistry with an emphasis on basic principles and their applications. Subject 5.112 is intended for students with a strong background in high school chemistry.

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, which is offered in several versions in the fall term. Of these, 18.02 is the most basic version. 18.022 is somewhat more theoretical, and 18.023 emphasizes applications. Each of these options presents 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 8.01L 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.

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 taken 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 subject by the end of their second term at the Institute.

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): 21F.222 Expository Writing for Bilingual Students; 21L.000/21W.734J Writing About Literature; 21W.730 Writing on Contemporary Issues; 21W.731 Writing and Experience; and 21W.732 Science Writing and New Media.

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 subjects 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. These CI-M subjects may be used to fulfill the communication component of two majors simultaneously if the subject is approved by petition to the Subcommittee on the Communication Requirement and by both departments.

**Second SB degree (for students who entered prior to the 2008–2009 academic year).** Students who wish to receive two SB degrees 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. However, a CI-M subject may be used to fulfill the communication component of two degrees simultaneously if the subject is approved by petition to the Subcommittee on the Communication Requirement and by both departments. To be consistent with MIT policy on two SB degrees, departments should approve a student’s proposed program only if the CI-M subjects in the program would be acceptable for a single degree.

**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 (of at least 9 units each) in the humanities, arts, and social sciences. Two of the HASS subjects that are designated Communication Intensive may be used toward the Communication Requirement. See the description of the Communication Requirement earlier in this section.

**Distribution.** Three of the eight subjects must be chosen from a specially designated list of distribution subjects in the 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 HASS-D Requirement by the end of their junior year. Refer to the section below on the HASS Distribution Subjects for specifics.

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

Currently, the following **fields of concentration** are offered:

- American Studies
- Ancient and Medieval Studies
- Anthropology
- Archaeology and Archaeological Science
- Black Studies
- Comparative Media Studies
- East Asian Studies
- Economics
- Ethics
- Ethnic Studies
- Foreign Languages and Literatures
  - **Chinese, ELS, French, German, Japanese, Spanish**
- History
- History of Art and Architecture
- Labor in Industrial Society
- Latin American Studies
- Linguistics
- Literature
- Middle Eastern Studies
- Music
- Philosophy
- Physical Imagination (Dance)
- Political Science
- Psychology
- Religious Studies
- Russian Studies
- Science, Technology, and Society
- Studies in International Literature and Cultures
- Theater Arts
- Urban Studies
- Visual Arts and Design
- Women’s and Gender Studies
- Writing

Students interested in exploring or registering for a field of concentration should speak with an advisor designated by that field.
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, visit the HASS Education Office, Room 14N-410, 617-253-4441, hass-www@mit.edu, or check the HASS Education Office home page at http://hass.mit.edu/undergraduate/.

HASS Distribution Subjects

Humanities, Arts, and Social Sciences Distribution (HASS-D) subjects are humanistic in orientation, of broad general interest, with a subject matter clearly drawn from one or more of the disciplines in the humanities, arts, and social sciences. Such subjects meet in sections small enough to allow discussions in which every student can participate, and—except for some art and music composition subjects—call for a substantial amount of writing.

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

Students are free to take more than the necessary minimum of three distribution subjects; those taken in excess of the minimum may be used as electives toward completion of the eight-subject requirement or in some cases, with the approval of the relevant field advisor, may be accepted as part of a program of concentration. Note, however, that in no case may more than one subject in a given category be counted toward distribution.

The Humanities, Arts, and Social Sciences Distribution (HASS-D) Requirement was introduced in 1988 to provide increased intellectual structure and cohesion. The HASS-D Requirement is meant to complement the General Institute Requirement in Science, emphasizing modes of inquiry and discourse that are qualitative and contextual. HASS-D subjects aim to develop substantive knowledge and analytical skills. They are to have a broad intellectual range and include a generous view of the alternative and often competing assumptions, perspectives, and intellectual tendencies in the field. They are to incorporate, where appropriate, materials and insights drawn from the full range of contemporary scholarship, including that on women, minorities, and nonwestern cultures.

HASS-Distribution Requirement

Undergraduates must take three 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.

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 2009–2010 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.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>21F.022</td>
<td>International Women’s Voices [SP.461J]</td>
</tr>
<tr>
<td>21F.311</td>
<td>Introduction to French Culture</td>
</tr>
<tr>
<td>21F.716</td>
<td>Introduction to Contemporary Hispanic Literature and Film</td>
</tr>
<tr>
<td>21L.003</td>
<td>Reading Fiction</td>
</tr>
<tr>
<td>21L.004</td>
<td>Reading Poetry</td>
</tr>
<tr>
<td>21L.006</td>
<td>American Literature</td>
</tr>
<tr>
<td>21L.007</td>
<td>World Literatures</td>
</tr>
<tr>
<td>21L.009</td>
<td>Shakespeare</td>
</tr>
<tr>
<td>21L.012</td>
<td>Forms of Western Narrative</td>
</tr>
<tr>
<td>21L.421</td>
<td>Comedy</td>
</tr>
<tr>
<td>21W.735</td>
<td>Writing and Reading the Essay</td>
</tr>
<tr>
<td>21W.775</td>
<td>Writing about Nature and Environmental Issues</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>21F.059</td>
<td>Paradigms of European Thought and Culture</td>
</tr>
<tr>
<td>21L.001</td>
<td>Foundations of Western Culture: Homer to Dante</td>
</tr>
<tr>
<td>21L.002</td>
<td>Foundations of Western Culture: The Making of the Modern World</td>
</tr>
<tr>
<td>21L.017</td>
<td>The Art of the Probable</td>
</tr>
<tr>
<td>21L.448J</td>
<td>Darwin and Design [21W.739J]</td>
</tr>
<tr>
<td>21W.742J</td>
<td>Writing about Race [SP.575J]</td>
</tr>
<tr>
<td>21W.747</td>
<td>Rhetoric</td>
</tr>
<tr>
<td>24.00</td>
<td>Problems of Philosophy</td>
</tr>
<tr>
<td>24.01</td>
<td>Classics of Western Philosophy</td>
</tr>
<tr>
<td>24.02</td>
<td>Moral Problems and the Good Life</td>
</tr>
<tr>
<td>24.04J</td>
<td>Justice [17.01J]</td>
</tr>
<tr>
<td>24.06J</td>
<td>Bioethics [STS.006J]</td>
</tr>
<tr>
<td>24.09</td>
<td>Minds and Machines</td>
</tr>
<tr>
<td>24.900</td>
<td>Introduction to Linguistics</td>
</tr>
<tr>
<td>STS.011</td>
<td>American Science: Ethical Conflicts and Political Choices</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.301</td>
<td>Introduction to Visual Arts</td>
</tr>
<tr>
<td>4.601</td>
<td>Introduction to Art History</td>
</tr>
<tr>
<td>4.602</td>
<td>Modern Art and Mass Culture</td>
</tr>
<tr>
<td>4.605</td>
<td>Introduction to the History and Theory of Architecture</td>
</tr>
<tr>
<td>4.614</td>
<td>Religious Architecture and Islamic Cultures</td>
</tr>
<tr>
<td>21L.005</td>
<td>Introduction to Drama</td>
</tr>
<tr>
<td>21L.011</td>
<td>The Film Experience</td>
</tr>
<tr>
<td>21L.016</td>
<td>Learning from the Past: Drama, Science, Performance [meets with 21M.616J]</td>
</tr>
</tbody>
</table>
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 [17.30]
14.63 The American Labor Force in a Changing Economy
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
17.55J Introduction to Latin American Studies [21A.224, 21F.084]
21A.100 Introduction to Anthropology
21A.109 How Culture Works
21F.064 Introduction to Japanese Culture [meets with 21F.592]
21F.076 Globalization: The Good, the Bad, and the In-Between
21F.592 Introduction to Japanese Culture [meets with 21F.064]
21W.784 Becoming Digital: Writing about Media Change
CMS.100 Introduction to Media Studies
SP.401 Introduction to Women’s and Gender Studies
SP.409 Women and Global Activism in Media and Politics
STS.010 Neuroscience and Society

Category 5: Historical Studies

Subjects in this category study the development of people, institutions, or countries over a considerable period of time.

21H.001 How to Stage a Revolution
21H.102 American History Since 1865
21H.105 American Classics
21H.301 The Ancient World: Greece
21H.302 The Ancient World: Rome
21H.416J Medieval Economic History in Comparative Perspective [14.70]
21H.421 Introduction to Environmental History
21H.433 The Age of Reason: Europe from the 17th to the Early 19th Centuries
21H.504 East Asia in the World, 1500–2000 A.D.
21H.523 History of Modern Japan, 1853–2000
21H.601 Islam, the Middle East, and the West
21H.912 The World Since 1492
21W.746 Humanistic Perspectives on Medicine: From Ancient Greece to Modern America

Enrollments in some HASS-D subjects may be limited. Students who did 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 Education Office in order to exercise this option. All other students enter their preferences 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/ or contact the HASS Education Office, 14N-410, 617-253-4441, hass-www@mit.edu.

Elective Subjects

The remainder of the eight-subject requirement, above and beyond Distribution and Concentration, may be fulfilled by approved subjects in the humanities, arts, and social sciences. These elective subjects may be chosen from among most undergraduate subjects offered in the School of Humanities, Arts, and Social Sciences, a substantial number of subjects in the School of Architecture and Planning, and a smaller number from the other schools. Subjects which may be used to fulfill the HASS Requirement without petition are designated as HASS subjects in the online MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.

Appropriate subjects taken by cross-registration at Harvard University or Wellesley College may also count toward the requirement. However, in most cases a petition must be submitted. Graduate subjects (designated as G subjects in the online MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi) may be used to satisfy the requirement only by petition to the Committee on Curricula; the instructor’s signature must be included on the petition.

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**

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>Introduction to Computers and Engineering Problem Solving</td>
</tr>
<tr>
<td>1.018J</td>
<td>Ecology I: The Earth System [7.30J]</td>
</tr>
<tr>
<td>1.050</td>
<td>Engineering Mechanics I</td>
</tr>
<tr>
<td>2.001</td>
<td>Mechanics and Materials I</td>
</tr>
<tr>
<td>2.003J</td>
<td>Dynamics and Control I [1.053J]</td>
</tr>
<tr>
<td>2.005</td>
<td>Thermal-Fluids Engineering I</td>
</tr>
<tr>
<td>3.012</td>
<td>Fundamentals of Materials Science and Engineering</td>
</tr>
<tr>
<td>3.021</td>
<td>Introduction to Modeling and Simulation [1.021,10.333, 22.00]</td>
</tr>
<tr>
<td>3.046</td>
<td>Thermodynamics of Materials</td>
</tr>
<tr>
<td>4.440</td>
<td>Building Structural Systems</td>
</tr>
<tr>
<td>5.07J</td>
<td>Biological Chemistry I [20.507J]</td>
</tr>
<tr>
<td>5.12</td>
<td>Organic Chemistry I</td>
</tr>
<tr>
<td>5.60</td>
<td>Thermodynamics and Kinetics</td>
</tr>
<tr>
<td>5.61</td>
<td>Physical Chemistry</td>
</tr>
<tr>
<td>6.00</td>
<td>Introduction to Computer Science and Programming</td>
</tr>
<tr>
<td>6.002</td>
<td>Circuits and Electronics</td>
</tr>
<tr>
<td>6.041</td>
<td>Probabilistic Systems Analysis</td>
</tr>
<tr>
<td>6.042J</td>
<td>Mathematics for Computer Science [18.062J]</td>
</tr>
<tr>
<td>6.071J</td>
<td>Electronics, Signals, and Measurement [22.071J]</td>
</tr>
<tr>
<td>7.03</td>
<td>Genetics</td>
</tr>
<tr>
<td>7.05</td>
<td>General Biochemistry</td>
</tr>
<tr>
<td>8.03</td>
<td>Physics III</td>
</tr>
<tr>
<td>8.04</td>
<td>Quantum Physics I</td>
</tr>
<tr>
<td>8.20</td>
<td>Introduction to Special Relativity</td>
</tr>
<tr>
<td>8.21</td>
<td>Physics of Energy</td>
</tr>
<tr>
<td>8.282J</td>
<td>Introduction to Astronomy [12.402J]</td>
</tr>
<tr>
<td>8.286</td>
<td>The Early Universe</td>
</tr>
<tr>
<td>9.01</td>
<td>Introduction to Neuroscience</td>
</tr>
<tr>
<td>10.301</td>
<td>Fluid Mechanics</td>
</tr>
<tr>
<td>12.001</td>
<td>Introduction to Geology</td>
</tr>
<tr>
<td>12.002</td>
<td>Physics and Chemistry of the Terrestrial Planets</td>
</tr>
<tr>
<td>12.003</td>
<td>Physics of the Atmosphere and Ocean</td>
</tr>
<tr>
<td>12.102</td>
<td>Environmental Earth Science</td>
</tr>
<tr>
<td>12.400</td>
<td>The Solar System</td>
</tr>
<tr>
<td>12.425</td>
<td>Extrasolar Planets: Physics and Detection Techniques</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.30</td>
<td>Introduction to Statistical Method in Economics</td>
</tr>
<tr>
<td>16.001</td>
<td>Unified Engineering I</td>
</tr>
<tr>
<td>18.03</td>
<td>Differential Equations</td>
</tr>
<tr>
<td>18.034</td>
<td>Differential Equations</td>
</tr>
<tr>
<td>18.036</td>
<td>Differential Equations</td>
</tr>
<tr>
<td>18.05</td>
<td>Introduction to Probability and Statistics</td>
</tr>
<tr>
<td>18.06</td>
<td>Linear Algebra</td>
</tr>
<tr>
<td>18.700</td>
<td>Linear Algebra</td>
</tr>
<tr>
<td>20.110J</td>
<td>Thermodynamics of Biomolecular Systems [2.772J]</td>
</tr>
<tr>
<td>22.01</td>
<td>Introduction to Ionizing Radiation</td>
</tr>
<tr>
<td>22.02</td>
<td>Introduction to Applied Nuclear Physics</td>
</tr>
</tbody>
</table>

**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>Subject Code</th>
<th>Subject Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.101</td>
<td>Introduction to Civil and Environmental Engineering Design I [0-3-3]</td>
</tr>
<tr>
<td>1.102</td>
<td>Introduction to Civil and Environmental Engineering Design II [1-3-2]</td>
</tr>
<tr>
<td>1.106</td>
<td>Environmental Fluid Transport Processes and Hydrology Laboratory [0-4-2]</td>
</tr>
<tr>
<td>1.107</td>
<td>Environmental Chemistry and Biology Laboratory [0-4-2]</td>
</tr>
<tr>
<td>2.008</td>
<td>Design and Manufacturing II [3-3-6] [gives 6 units of laboratory credit]</td>
</tr>
<tr>
<td>2.017J</td>
<td>Design of Electromechanical Robotic Systems [3-4-5] [1.015J]</td>
</tr>
<tr>
<td>2.671</td>
<td>Measurement and Instrumentation [3-3-6]</td>
</tr>
<tr>
<td>2.672</td>
<td>Project Laboratory [0-3-3]</td>
</tr>
</tbody>
</table>
Part 42

24.909 Field Methods in Linguistics (3-1-8)

20.109 Laboratory Fundamentals in Biological Engineering (2-8-5)

18.821 Project Laboratory in Mathematics (3-6-3)

17.871 Political Science Laboratory (3-6-6)

16.831 J Space Systems Development I (2-6-4) [12.431J] [gives 6 units of laboratory credit]

16.821 Flight Vehicle Development (2-10-6)

16.622 Experimental Projects II (3-6-3)

15.301 Managerial Psychology Laboratory (3-3-9) [gives 12 units of laboratory credit]

14.33 Research and Communication in Economics: Topics, Methods, and Implementation (3-4-5)

13.014 Materials Laboratory (1-4-7)

12.410 J Observational Techniques of Optical Astronomy (3-4-8) [8.287J]

12.335 Experimental Atmospheric Chemistry (2-4-6) [meets with 12.835]

12.307 Weather and Climate Laboratory (1-4-7)

12.119 Analytical Techniques for Studying Environmental and Geologic Samples (2-6-4)

11.188 Urban Planning and Social Science Laboratory (3-6-3)

10.467 Polymer Science Laboratory (2-7-6)

10.702 Introduction to Experimental Biology and Communication (4-8-6) [meets with 10.702, listed below]

9.61 Laboratory in Higher Level Cognition (3-6-3)

9.50 Research in Brain and Cognitive Sciences (2-8-2)

9.33 Research and Communication in Economics: Topics, Methods, and Implementation (3-4-5)

9.12 Experimental Molecular Neurobiology (2-4-6)

8.13 Experimental Physics I (0-6-12)

8.14 Experimental Physics II (0-6-12)

8.12 Experimental Chemistry I (2-8-2)

8.11 Experimental Chemistry II (2-8-2)

8.01 Introduction to EECS I (2-4-6) [gives 6 units of laboratory credit]

8.02 Introduction to EECS II (3-3-6) [gives 6 units of laboratory credit]

7.02 Introduction to Experimental Biology and Communication (4-8-6) [meets with 10.702, listed below]

6.182 Psychoacoustics Project Laboratory (3-6-3)

6.161 Modern Optics Project Laboratory (3-5-4)

6.163 Strobe Project Laboratory (2-8-2)

6.111 Introductory Digital Systems Laboratory (3-7-2)

6.102 Introductory RF Design Laboratory (2-9-1)

6.101 Introductory Analog Electronics Laboratory (2-9-1)

6.02 Introduction to Experimental Physics (2-6-4) [gives 6 units of laboratory credit]

6.01 Introduction to EECS I (2-4-6) [gives 6 units of laboratory credit]

5.35 Introduction to Experimental Chemistry (2-8-2)

4.411 Building Technology Laboratory (2-4-6)

3.014 Materials Laboratory (1-4-7)

Undergraduate Education

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 must take four physical education classes (for 8 points) and complete the swim requirement. The swim 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 classes, students may earn physical education points in the following ways:

- Varsity sports: Four points are awarded to players in their major season of competition.
- ROTC Programs (Air Force, Army, Navy): Two points are awarded per year of ROTC participation up to a maximum of four units.

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. Students must attend 11 of 12 sessions to receive the 2 points for a physical education course. Freshmen are expected to complete the swim test during fall registration day or, if they can’t swim, register for a swim class during first quarter. 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.

Physical education classes 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 class per quarter. Students who enter as freshmen are required to complete eight points (four classes). Transfer students need to complete four points (two classes), as well as the swimming requirement. A student may repeat a class at any level and receive points for the class.

Physical education registration is open to the entire MIT community. Registration is conducted online at http://mitpe.com/. Information on registration can be obtained through WebSIS at http://student.mit.edu/.

Physical education classes offered last year included Group Exercise (Total Body Conditioning, Kickboxing, Pilates, Step, Yoga), Archery, Backpacking/Hiking, Badminton, Basketball, Cross-Country Ski, Dance (Modern, Choreography, Square, Folk), Fencing, Figure Skating, Golf, Gymnastics, Ice Hockey, Juggling, Kayaking, Martial Arts (Aikido, Jiujitsu, Shotokhan, Sport Taekwondo, Tae Kwon Do), Pistol, Ropes Adventure, Running/Logging, Sailing, Scuba, Skating, Skiing/Snowboarding, Soccer (indoor), Squash, Tennis, Volleyball, and Weight Training.
Students must wear appropriate attire for activity classes. Most classes provide all necessary equipment. Students must supply skates and sticks for ice hockey classes, and rackets for tennis classes. Nonmarking 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 to gain access to all sport facilities at no additional charge during the academic year. There is a nominal fee to access sport facilities in the summer.

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 topic” 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. The meal plan spans the entire academic year and includes IAP. 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 ame-
nable 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, 617-253-6771, firstyear-www@mit.edu.

Undergraduate Seminars and Freshman Advising Seminars

Undergraduate seminars, offered in the fall and spring terms, provide undergraduates with an opportunity to interact closely with faculty on topics of current interest. Freshman Advising Seminars are a special subset of seminars open only to first-term freshmen, in which the seminar leader is also the freshman advisor to the seminar participants. Seminars vary tremendously both in style and topic. Some are oriented around small group discussion; others have speakers, go on field trips, or engage in hands-on learning. All seminars carry six units of credit, and the class size is restricted to a small group. All seminars are graded P/D/F.

Information about undergraduate seminars, including titles and descriptions, can be found at [http://student.mit.edu/catalog/Undergraduate_Seminars.html](http://student.mit.edu/catalog/Undergraduate_Seminars.html). Information about Freshman Advising Seminars, including title, descriptions, and application information for incoming freshmen, can be found at [http://web.mit.edu/firstyear/](http://web.mit.edu/firstyear/). These websites are maintained by the Office of Undergraduate Advising and Academic Programming, Room 7-104, 617-253-6771, firstyear-www@mit.edu.

Edgerton Center

The Edgerton Center provides resources and opportunities for students to pursue hands-on projects, activities, and seminars. 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 ([http://web.mit.edu/Edgerton/www/Shop.html](http://web.mit.edu/Edgerton/www/Shop.html)) is located in Room 44-023 and offers regular training sessions; contact manager Mark Belanger at mdbelang@mit.edu for access and training.

Typical subjects offered include introductory electronics, digital photography, seminars for public service, and alternative energies. In addition, the strobist project laboratory (6.163) is taught each term. During IAP, staff members lead workshops teaching technical skills that many students find useful for UROP projects. 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).

The Edgerton Center is the joint sponsor of the Service Learning Initiative at MIT with the Public Service Center, bringing community service projects into the academic curriculum. It is also cosponsor of the IDEAS Competition, promoting innovative projects that benefit communities, both local and international. For more information about Service Learning opportunities contact servicelearning@mit.edu, or call 617-258-0872. For more information on the IDEAS Competition, email ideas-admin@mit.edu.

D-Lab is a yearlong series of classes and field trips that begins in the fall with a class on international development and appropriate technology, SP.721J/11.025J; SP.722J/11.472. Over IAP, students travel overseas to work with local community partners in developing countries to identify projects they can work on during the spring term design seminars, including subjects SP.722J/2.722J and SP.723. For more information about D-Lab, contact Amy Smith at 617-253-5985, abs@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 617-253-7931 or amyfitz@mit.edu to become involved.

The center also supports a range of hands-on student activities, including the Solar Electric Vehicle Team, BEInG (Biological Energy Interest Group), FIRST Robotics Team, Formula SAE, and a variety of other engineering groups. If you are interested in starting up a new team, contact Steven Banzaert, sgtist@mit.edu.

In addition, Professor Harold Edgerton’s high-speed photography legacy lives on with the Strobe Alley exhibition of Edgerton photographs. Hands-on experiments in science and engineering are attractions of the corridor laboratory as well.

The center offers UROP projects for students in engineering design, high-speed video motion analysis, scientific photography, and community outreach. Positions are also available for student instructors at the center throughout the year.

The faculty director of the Edgerton Center is Professor J. Kim Vandiver, Room 4-405, kimv@mit.edu. For general information, contact Sandi Lipnoski, Room 4-405, 617-253-4629, slipnosk@mit.edu, or visit [http://web.mit.edu/edgerton/main.html](http://web.mit.edu/edgerton/main.html).

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 and they 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 social experiences. Through the cross-registration programs students can take subjects not offered at MIT or explore institutions emphasizing other curricula while continuing their studies at MIT.

Study Abroad Opportunities

Cambridge-MIT Undergraduate Student Exchange Program
The Cambridge-MIT Undergraduate Student Exchange Program (CME), 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 Dean Brian Wahl, 617-715-5331, bwahl@mit.edu, or their departments. A list of CME faculty coordinators and administrators in each department can be found at http://web.mit.edu/cmi/ue/cme-mit/mit-how-to-apply.html.

MIT-Madrid Program
The MIT-Madrid Program gives students the opportunity to study in Madrid for the spring term. 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. 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://web.mit.edu/studyabroad/before/mit-madrid.html.

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 the Global Education Office, 12-189, studyabroad@mit.edu.

IAP-Germany Immersion Course
The IAP-Germany Immersion Course also will be offered to MIT undergraduate and graduate students. For more information contact Dr. Sigrid Berka, 617-253-6982, sberka@mit.edu.

Departmental Exchange Programs

The Department of Aeronautics and Astronautics offers study at several European schools as well as at the University of Pretoria in South Africa. For more information contact the Global Education Office, 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.

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 as 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 the Global Education Office, 12-189.

Students interested in study abroad should begin planning as early as possible. They should meet with a staff member in the Global Education Office and work out their plans with a faculty advisor and appropriate transfer credit examiner(s) in the department. They also must complete a Worksheet for Planning Study Abroad/Domestic Study Away (http://web.mit.edu/studyabroad/before/forms.html) in order to gain approval for study abroad. While on an approved study abroad program during the fall and/or spring term(s), a student maintains full-time student status at MIT. Although it is most common to study abroad during the junior year, it is...
also possible to participate in a study abroad program in the sophomore year or, in some cases, in the senior year as well as during IAP and/or summer.

Financial aid is portable for study abroad. Students who receive financial aid at MIT are advised to discuss their study abroad plans with the Student Financial Aid Office at least one term prior to the term in which they wish to commence study abroad. This will help students develop the best possible financial plans for their time abroad.

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 work 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 the Global Education Office, Room 12-189, studyabroad@mit.edu or visit http://web.mit.edu/geo/.

Internships Abroad
In addition to study abroad programs, MIT students may gain international experience by working as interns in companies or research institutes abroad. The MIT International Science and Technology Initiatives (MISTI) offer internship opportunities in China, France, Germany, India, Italy, Japan, Mexico, Singapore, and Spain. Internships range from three months to one year. All expenses are usually covered. Arrangements after graduation are also possible. 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/.

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 the Global Education Office, 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://web.mit.edu/studyabroad/before/forms.html).

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 work 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 the Global Education Office, Room 12-189, studyabroad@mit.edu or visit http://web.mit.edu/geo/.

Cross-registration Programs
Harvard University
MIT undergraduates are permitted to take subjects at Harvard University (except Harvard Business School, Harvard Extension 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.


Wellesley College
Under the Wellesley-MIT Exchange Program, students may cross-register for any courses at the other school, if they present the necessary prerequisites. This cooperative arrangement is not applicable to the IAP or summer sessions. Wellesley is a small, liberal arts college for women located on a 500-acre woodland campus 20 miles west of Boston.

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.

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

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 generally cannot substitute Wellesley subjects for MIT Science Requirement subjects (Chemistry, Biology, Physics, and Calculus) or 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.

Wellesley 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. Students may use Wellesley courses as unrestricted electives toward fulfilling the Humanities, Arts, and Social Sciences Requirement, but they must petition to do so.

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

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.

Detailed information on registration procedures is available at http://web.mit.edu/registrar/reg/xreg/MITtoWellesley.html. The Exchange Office at Wellesley is located in Room 339C, Green Hall, 781-283-2325 or MIT tie line 187-2325.

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 and with Tufts University. 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 may be taken per term from either school.

This cooperative arrangement is not applicable to the summer session or IAP.

Students must submit a completed cross-registration form by the deadline set by the MIT Registrar. The cross-registration form is available in the Student Services Center, Room 11-120. Detailed information is available at http://web.mit.edu/vap/about/xreg.html.

**CAREER AND PROFESSIONAL OPTIONS**

**Global Education and Career Development Center**

The Global Education and Career Development Center (GECDC) 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
- Preprofessional Advising
- Employment Recruitment Services
- Global Education

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 and visiting the center’s website (http://careers.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 contribute to society
- Career options in relation to choice of major
- Internships, externships, 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.

Students interested in exploring and applying to law or medical, dental, or other health-related professional schools are supported by the Preprofessional Advising staff in the GECDC, Room 12-170. Students from all majors can apply to law and health-related professional schools. However, individuals interested in a health profession must fulfill certain subject requirements. Students should visit http://web.mit.edu/career/www/preprof/ for information on admissions criteria, the application process, the advisor assignment process, and services provided.

The center’s 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.

The Global Education Office provides comprehensive support to undergraduates interested in studying abroad as well as expertise and consultation to faculty and program directors. The office acts as a one-stop office for information on MIT global education opportunities, helping students investigate and prepare for global opportunities that best fit their academic and life interests as well as integrating the global experience into their life at MIT and career. The office manages study abroad programs.
and processes directly and works with partner programs such as the UROP Office, Public Service Center, and MISTI 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. For further information, contact the Global Education and Career Development Center, Rooms 12-189 (Global Education) or 12-170 (Career Development), 617-253-4733, fax 617-253-8457, or visit http://gecdc.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/Welllesley 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 Course 11 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/tep/.

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.

ROTC 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 150 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 physical training credit and 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 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.
- Federal law and Department of Defense regulations presently exclude from the Armed Forces people who engage in homosexual conduct. (ROTC academic classes, however, are open to all students regardless of their sexual orientation.)
- 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 can 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 of 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 while 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. Aerospace Studies offers two programs—one of four years and one of two years—for students to qualify for commissions.
Four-Year Program
The four-year 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 those 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 lieu of completing the GMC, these students receive five weeks of field training at an Air Force base during the summer between their two years. 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, include $900 per year for textbooks, and a $300–500 nontaxable allowance each month. One- 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. All eligible recipients of partial scholarships have the opportunity to compete for scholarship upgrades ranging from 80% to 100% tuition.

Program of 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.

Extracurricular Events
Throughout the four years of the program, cadets also have many optional extracurricular opportunities to expand their leadership skills and interact with the active duty Air Force. Many students visit Air Force bases all over the country, participate in military orientation flights, receive civilian flight training, and offer their service to others in our national service organization, the Arnold Air Society. In the summer, students can also apply for a variety of internships—15 in all—including flying gliders, participating as a field engineer, or foreign language immersion by living abroad.

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, Endicott College, Gordon College, Harvard University, Salem State College, 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 are awarded a commission as a Second Lieutenant in the US Army. 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 five-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 one-and-a-half years 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 may participate in a four-week training camp (the Leader's Training Course) at Fort Knox, KY, in lieu of completing the Basic Course (freshman and sophomore years). Once students com-
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. 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 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 hours per week. Students also participate in a monthly Leadership Lab that highlights a particular military activity. Finally, students participate in a field training exercise each term that includes small unit leadership training, military tactics, land navigation, rappelling, obstacle negotiation, and 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, Endicott College, Gordon College, or Salem State College 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 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 sub-
ject 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

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 visits. The application will be available online beginning in the summer of the year prior to proposed entry. Candidates must complete the application process by January 1 of the year of intended entrance. Early Action (available to citizens and permanent residents of the United States only) has a November 1 deadline. There is a $75 application fee.

Personal Conferences

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. This conference must be scheduled before December 10 of the year prior to entrance (before October 20 for Early Action applicants).

Campus Tours

Prospective applicants and their families are welcome to visit the Admissions Office Monday through Friday between 9 am and 5 pm. Student-guided tours of the campus are offered year-round each weekday (except holidays) at 11:00 am and 3:00 pm. From April through November, the tours are directly preceded by a group information session (10:00 am and 2:00 pm) in Room 10-100.

Interphase

Interphase is a rigorous seven-week summer residential academic and community-building program for admitted MIT freshmen that instills subject mastery of calculus, physics, and chemistry, and helps them explore their cultural identities through reading, writing, and discussion. In addition, students take physical education classes and participate in small-group learning activities and workshops designed to develop their analytical thinking and communication skills. These endeavors should position them to thrive during their MIT academic careers. Extracurricular activities include day trips to area cultural, recreational, and industrial sites. Ample opportunities to begin building social networks and faculty connections are provided. For incoming students of all races and national origins, the program offers a rich, multicultural educational experience that prepares them to become both leaders on campus and in the increasingly diverse global society. Students can earn academic credit upon successful completion of the coursework, giving them a head start towards fulfillment of their graduation requirements.

For more information, write to the Office of Minority Education, Room 4-113.

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 any reason except full-time enrollment at another university.

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; GCE/GCSE A-levels, the...
International Baccalaureate, and other foreign exams; college transcript; and Advanced Standing Examination at MIT.

Students who take college-level subjects offered in their schools in cooperation with the College Board Advanced Placement Program should take the appropriate examinations administered by the board each year in May and instruct the board to send the scores to MIT. Degree credit for MIT subjects and, where appropriate, advanced placement, is given on the basis of a high achievement on the tests (in most cases a score of 5). A score of 5 on humanities, arts, and social sciences tests recognized by MIT will enable students to receive credit (9 units) applicable to the unrestricted elective requirements only. This credit does not reduce the General Institute Requirements 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 receive MIT credit under the regular college transfer procedures.

Students will be notified about the credit offered before registration.

**Entrance Examinations**

All candidates are required to complete one of the following testing options.

- For native English speakers: the SAT Reasoning Test or the ACT with Writing, and two SAT Subject Tests (one in biology, chemistry, or physics; the other in mathematics level 1 or mathematics level 2).

- For non-native English speakers: the TOEFL (Test of English as a Foreign Language) and two SAT Subject Tests (one in biology, chemistry, or physics; the other in mathematics level 1 or mathematics level 2).

Alternatively, non-native English speakers may choose to complete the testing requirement for native English speakers (see above).

The last acceptable testing date for freshman admission to the Class of 2014 is the January 2010 testing date. If you take the January test, 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 from the Internet at [http://www.collegeboards.com/](http://www.collegeboards.com/), 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.

**Early Action**

*Early action is available only to citizens and permanent residents of the United States.*

A student who takes all the required tests by the November test date, and files all of the application material no later than November 1 may request the Committee on Admissions to review the application by 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 of May 1.

**Facility in English**

Lectures, laboratory sessions, and written or 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 may be considered for transfer admission.

A transfer student’s eligibility for admission will be determined by the Committee on Admissions after a review of his or her record. The Admissions Office welcomes inquiry from all transfer applicants.

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.

All candidates are required to complete one of the following testing options.

- For native English speakers: the SAT Reasoning Test and two SAT Subject Tests (one in biology, chemistry, or physics; the other in mathematics level 1 or mathematics level 2).

- For non-native English speakers: the TOEFL (Test of English as a Foreign Language) and two SAT Subject Tests (one in biology, chemistry, or physics; the other in mathematics level 1 or mathematics level 2).

Alternatively, non-native English speakers may choose to complete the testing requirement for native English speakers (see above).

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**

Applicants must submit the following documents:

- A completed application for transfer admission with a nonreturnable fee of $75. Final applications should be submitted by March 15 for entry in September and by November 15 for entry in February.
- 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

Applicants will be informed of decisions six to eight weeks after the application deadlines. In some cases, action may be deferred until final grades are available.
Financial Aid
Information on financial aid is included with final application forms.

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. The students enroll as special students; they enjoy most of the privileges of the regular student but are not eligible for campus housing or financial assistance from MIT. Students wishing to apply for special student status should contact the Office of Admissions at 617-253-4770.

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 subject to available places in the classroom or laboratory.

The Admissions Office will supply application forms upon request.
There is an application fee of $75. The fee will cover two sequential terms. A new application is required for each subsequent term.

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 2009–2010 at MIT will be about $52,000. This includes $37,782 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 $2,850. 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 $11,360 for room and meals. Actual costs for 2009–2010 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 2009–2010 (which are reviewed and likely to increase each year):

- Tuition: $37,510
- Student Activity Fee: $272
- MIT Student Extended Insurance Plan (optional): $1,656

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/.

The tuition for all regular undergraduates in the fall and spring terms is $18,755 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 $585 per unit with the approval of the faculty advisor. In such cases, there is a minimum fee of $3,560 for subjects and a minimum of $1,560 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 $585 per unit taken either for credit or not for credit. This unit fee applies up to a maximum of $18,755 per term and is subject to the following minimum fees:

- Members of the MIT community: $3,560 (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: $5,335

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
- Materials Science and Engineering, Course 3-B

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:

<table>
<thead>
<tr>
<th>Fee Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application fee for undergraduate admission</td>
<td>$75</td>
</tr>
<tr>
<td>Fee for late submission of preregistration</td>
<td>$40</td>
</tr>
<tr>
<td>Fee for late filing of the degree application</td>
<td>$40</td>
</tr>
<tr>
<td>Fee for late initiation of the registration process</td>
<td>$100</td>
</tr>
</tbody>
</table>

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 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 deadline, the MIT Payment Plan is available and should be considered.

Participation in the MIT Payment Plan allows an installment payment arrangement over four months each term (three months during the summer). A finance charge of 0.667 percent per month (8 percent annual percentage rate) is assessed on the unpaid account balance (excluding extended student medical insurance). To sign up for the plan, download the appropriate form at http://web.mit.edu/sfs/forms_and_publications/index.html and return it to SFS.

SFS also offer 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 of 33.3 percent of the outstanding balance.

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 (S3), 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 student account counselors in the Student Services Center, Room 11-120.

Policy on Undergraduate Financial Holds
Undergraduates with unpaid balances of more than $200 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 re-
garding financial holds. SFS will also provide Student Support Services and
the academic advisors with a list of undergraduates still carrying unpaid
balances.

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 pay-
ment 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 who do not settle their prior term balances or who
have not made efforts to resolve their financial problems will not be al-
lowed to register for the subsequent term or receive credit retroactively.
Students who face loss of services should immediately contact their
student account counselors 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 form. Copies of the most re-
cent 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 work 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/ 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 communi-
ties. 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 ob-
tained 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

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. 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 and return the International Student Financial Aid Application 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.

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 form. 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 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. Enrollment may be verified by submitting a copy of the approved registration form to the Veterans Administration (VA) coordinator in Student Financial Services, Room 11-320. Students may also wait until registration information appears online, typically the second week of the term. VA regulations require that benefits stop between the spring and fall terms if the period is greater than 60 days. Students with questions should consult with the VA coordinator.

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, and an $80 fine will be imposed on any entering 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 Qualified Student Health Insurance Plan (QSHIP). 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, 24-hour urgent care, 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, or by paying a Partner/Child MIT Student Medical Plan premium. 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. 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 30 for fall term, February 28 for spring term, and June 30 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. The Institute has traditionally been a national leader in engineering and science graduate education. In addition, 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 inter-disciplinary 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, 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://web.mit.edu/edge/gpp/.

Career Development

The Global Education and Career Development Center 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 the Global Education and Career Development Center, Room 12-170, 617-253-4733, fax 617-253-8457, or visit http://web.mit.edu/career/www/. See also the center’s 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.

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 164 units of G- or H-level subjects approved by the Department of Architecture, of which 96 units must be in H-level subjects, and the completion of a thesis acceptable to the Department of Architecture. The candidate must also have been in residence for a minimum of four regular academic terms. A student who enters without previous experience in a department of architecture may take as long as seven academic terms to complete the degree.

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 a program of study, including the first-term core classes and at least 144 units of G- or H-level subjects, acceptable to the Sloan School of Management (of which 42 units must be H-level). The candidate must also have been in residence for four consecutive 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).

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 as a graduate student for at least two consecutive academic terms (fall and spring). In most cases, a summer term is also required.

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 candidate must also have been in residence as a graduate student for at least two consecutive academic terms (fall and spring). 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. The
candidate must also have been in residence for two consecutive 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 the 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 graduate 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 also must 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)
- Metallurgical Engineer (MetE)
- 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
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. The degree of Doctor of Philosophy is awarded in architecture; biology; biomedical engineering; brain and cognitive sciences; economics; history, anthropology, and science, technology and society (HASTS); linguistics; management; media arts and sciences; philosophy; political science; technology and policy; toxicology; and urban studies and planning. These degrees certify creditable completion of an approved program of advanced study in addition to a research dissertation of high quality based on original research.

The two Institute requirements for a doctorate are 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 the 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, are not eligible for federal loan funds, and pay a substantially reduced tuition. However, they may receive payments from MIT for up to 5 percent of tuition for their first three nonresident terms. 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 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.

OTHER INSTITUTIONS

Harvard University
A regular, 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 his or her total registration for the term. Included in the above category are MIT full-time special graduate students. This cooperative arrangement is not applicable to the summer session.

Requests for registration under this cooperative arrangement must be approved by the 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 the transcripts of MIT graduate students 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 H-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 1993, 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 an annual gender studies conference. 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. GCWS 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. Graduate courses also provide crucial intellectual support for students pursuing feminist work within the framework of traditional disciplines. There is no fee for GCWS courses. Students are granted credit for participating by their home institutions. GCWS is currently administered at MIT.

Students in any discipline at MIT may register for GCWS seminars and receive graduate credit. Several seminars are offered per year; enrollment in each is limited. Graduate students 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/; 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 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.

Students wishing to enter in June or September should apply on the prescribed forms by December 15 (exceptions to that deadline are noted in the application packet); candidates for admission in February should apply by November 1. However, applications submitted later may be considered if vacancies still exist. 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.

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

Applications for admission should be requested from Graduate Admissions, Room 3-103, MIT. A $75 application fee must accompany all application forms; applications without the fee will not be accepted. Note that the Sloan School of Management should be contacted directly for application forms. The application fee is $230 for the Master’s Program in the Sloan School. All inquiries regarding graduate admission to the Sloan School are sent to the director of the master’s or doctoral program, whichever is appropriate: Room E52-112 (Master’s Program) or Room E52-003 (Doctoral Program), MIT, 50 Memorial Drive, Cambridge, MA 02142-1347.

Applications for readmission after an absence of one or more terms must be approved by the department.

Notification about admission for September is sent as soon as action is taken (usually before April 1); for February applicants, notification usually is sent as soon as the application is complete. Admission of a student who is in the final year of work toward a bachelor’s degree may be conditionally approved until subsequent evidence is provided that the degree has been awarded.

Inquiries about specific requirements for admission should be addressed to the appropriate graduate department.
Examinations
Many departments require applicants to submit scores on the Aptitude Test and the appropriate Advanced Test of the Graduate Record Examination (GRE). The requirements specified by the departments are included in the MIT graduate application material. For a test application, write to the Graduate Record Examination, Educational Testing Service, P.O. Box 955, Princeton, NJ 08540.

The Graduate Management Admission Test (GMAT) is required of all MBA applicants and must be taken before submitting an application for admission; as an alternative, MIT Sloan will also accept the Graduate Record Examination.

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.

The Graduate Application for Admission for International Students may be obtained from Graduate Admissions, Room 3-103 or, in the case of the Sloan School, from the director of either the master’s program, Room E52-112, or the doctoral program, Room E56-290. Applicants must submit complete application materials to the appropriate office.

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

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 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 a $75 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.

The term deadlines for filing special student applications are:
- Summer: May 1
- Fall: August 1
- Spring: January 1

Deadlines for international special student applicants are:
- Summer: March 1
- Fall: June 1
- Spring: November 1

International students living outside the United States are not permitted to apply for the summer term.
Permanent residents must submit a copy of the green card.
International students also need to submit copies of visas, and cannot cross-register at Harvard.
Applicants whose native language is not English must submit a photocopy of their TOEFL or IELTS score. Please visit the relevant department’s website for further information regarding minimum score requirements. The I-20 or IAP-66 will not be issued for subject registration of less than 36 units.

Admission as a special graduate student does not imply any commitment toward an individual’s admissibility to regular graduate student status. If a special graduate student is subsequently admitted as a degree candidate, subjects completed may be used in partial fulfillment of requirements for an advanced degree. The department will determine what subjects are acceptable. Registration as a special graduate student does not count toward minimum residency requirements for an advanced degree nor for eligibility for nonresident status. Correspondence concerning admission as a special graduate student should be addressed to the Special Student Admissions Office, Room 3-103, from whom application material and information for Special Students may be obtained.

Graduate Student Status for Research Staff Members
In view of their full-time responsibilities on assigned research and their corresponding salary scales, 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 2009–2010 (which are reviewed and likely to increase next year) are as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuition</td>
<td>$37,510</td>
</tr>
<tr>
<td>Student Activity Fee</td>
<td>$272</td>
</tr>
<tr>
<td>MIT Student Extended Insurance Plan (optional)</td>
<td>$1,656</td>
</tr>
</tbody>
</table>

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 section MIT Student Extended Insurance Plan in the section on Medical Requirements in this chapter, or visit [http://web.mit.edu/medical/](http://web.mit.edu/medical/).

The tuition for all regular students, including graduate student staff, in the first and second terms is $18,755 per term, except for students entering the Sloan Master’s Program and the Leaders for Global Operations Program, for whom the tuition is $24,325 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 $28,140 if not registered during the preceding regular term.

The tuition for all regular graduate students, including fellows, trainees, and academic staff in the 2009 summer session was $12,500. 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 $85 per unit whether taken for credit or not. This unit fee applies up to a maximum of $18,755 per term and is subject to the following minimum fees:

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Members of the MIT community</td>
<td>$3,560</td>
</tr>
<tr>
<td>(Includes special students who are full-time employees of the Institute or who are dependents of full-time employees or regular students.)</td>
<td></td>
</tr>
<tr>
<td>Other special students</td>
<td>$5,335</td>
</tr>
</tbody>
</table>

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 $1,560 per week from the starting date of the term, with a minimum of $1,560 for the master’s or engineer’s degree and $3,125 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 $9,380.

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 ($935 per term for 2009–2010). For the fourth and subsequent semesters of registration as a nonresident, tuition will equal approximately 15 percent of the regular full tuition ($2,810 per term for 2009–2010). 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 $9,380. Please consult Graduate Policies and Procedures ([http://web.mit.edu/odge/gpp/](http://web.mit.edu/odge/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
- Materials Science and Engineering, Course 3-B

The tuition fee for special graduate students in the Sloan School of Management (except for employees of the Institute or their children) is $1,024 per unit of registration, with a minimum charge of $9,290. There is a maximum charge of $33,500 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 $1,650 for a single graduate student, $2,200 for a married graduate student, and $2,500 for a married graduate student with one child. 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: $230
- Late submission of preregistration material: $40 (if very late)
- Late initiation of registration process or very late registration, or late submission of application for nonresident doctoral status: $100
- Late filing of degree application: $40 (if very late—see Academic Calendar)
- Late thesis title change: $75
- 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): $40
- 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 $40. There is an additional charge of $40 for a retroactive change at the end of the term.

The miscellaneous fees and processing charges listed above 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 changes (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.

Participation in the MIT Payment Plan allows an installment payment arrangement over four months each term (three months during the summer). The interest rate is currently 0.667 percent per month (8 percent annual percentage rate) and is assessed on the unpaid account balance (excluding extended student medical insurance). To sign up for the plan, download the appropriate form at http://web.mit.edu/sfs/forms_and_publications/index.html and return it to SFS.

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 of 33.3 percent of 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 MIT 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, scholarships, etc.) may receive supplementary stipends as teaching or research assistants in accordance with Institute and departmental guidelines.

**Loan Funds**


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.

For costs of education remaining after the maximum subsidized Federal Direct Subsidized Loan has been obtained, the Federal Direct Unsubsidized Loan may be available (for a combined total of $20,500). In determining need for these programs, as well as the Federal Direct Loan Program, 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. Information on these alternative programs, whose terms and conditions vary widely, is available from SFS Financial Aid, Room 11-320, or [http://web.mit.edu/sfs/loans/](http://web.mit.edu/sfs/loans/).

**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/](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/](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 aid may do paid community service. Wages are subsidized for students performing direct community 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/](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/](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. Enrollment may be verified by submitting a copy of the approved registration form to the Veterans Administration (VA) coordinator, Liz Barnes (barnes@mit.edu) in Student Financial Services, Room 11-320. Students may also wait until registration information appears online, typically the second week of the term. VA regulations require that benefits stop between the spring and fall terms if the period is greater than 60 days. Students with questions should consult with the VA coordinator.

**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](http://medweb.mit.edu/howdoi/guides/undergraduate.html#medreq).

Registration will not be permitted, and an $80 fine will be imposed on any entering 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 Qualified Student Health Insurance Plan (QSHIP). 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, 24-hour urgent care, 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, or by paying a Partner/Child MIT Student Medical Plan premium. 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. 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 30 for fall term, February 28 for spring term, and June 30 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? Is there student parking? This section contains the essential rules and regulations that govern day-to-day operations at MIT.
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 Forms must be approved by the student’s advisor or registration officer, signed by the student, and returned to the Registrar’s Office.

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 throughout 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 preregister 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. For applicants holding an associate’s degree or the equivalent, no credit used in obtaining that degree may be counted toward any MIT degree. A person wishing to be reinstated as a graduate student must apply for readmission through the Admissions Office and the student’s 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 classes 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/classrooms/exams/ase_exams.html](http://web.mit.edu/registrar/classrooms/exams/ase_exams.html).

Term Regulations and Examination Policies
These term regulations and examination policies, available at [http://web.mit.edu/faculty/teaching/termregs.html](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/](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 final examination period at the end of each term, and are scheduled through the Schedules Office. A final examination should 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.

Students are responsible for attending the final examinations in subjects for which they are registered. The schedule is issued several months before the examination period. Students are responsible for obtaining examination schedules. The Schedules Office will contact all students who have one or more conflicts; the conflict exam schedule will be published shortly after Drop Date.

After the Last Scheduled Class. No classes, examinations, or exercises of any kind may be scheduled after the last regular scheduled class in a subject except for final exams scheduled through the Schedules Office. Formal review should be held during regular class periods, but the rule does not exclude the possibility of sessions after the last day of classes at which the instructing staff is available to answer questions of students who choose to attend. (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.)

An instructor may give an extension to an individual student, 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. Undergraduates should contact a dean in Student Support Services and graduate students should contact the dean for graduate education if they wish to seek an excused absence; faculty members with questions about this process should contact the appropriate office. See definition of "O" and "OX" under Grades.

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

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 Exercise 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

**Final Examinations.** In some undergraduate subjects, final examinations may be *ex camera* (out-of-room) examinations. *Ex camera* examinations are a different mode of testing intended to give students access to computers and libraries and evaluate 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 *ex camera* final examinations. 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.** The Friday preceding the start of the Reading Period is defined as the Last Test Date. No tests will be held after this date until the Final Examination Period.

If a subject has a final examination, no assignment may fall due after the Last Test Date.

If a subject does not have a final examination, at most one assignment may fall due between the Last Test Date and the end of the last scheduled class period in the subject. This single assignment may include both an oral presentation and a written report if the two derive from the same project.

Optional assignments between the Last Test Date and the last scheduled class period in the subject should be for self-study, and may not be used toward part of the grade in a subject, even for extra points or as substitutes for earlier assignments.

**Graduate Subjects**

**Beginning of the Term.** By the end of the third week, the faculty member must provide:

- A clear and complete description of the required work, including the number and kinds of assignments
- The 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

**Tests and Academic Exercise Outside Scheduled Class Times.** A student who is unable to take a test that is held outside of scheduled class time owing to a conflict with another scheduled academic exercise or extracurricular activity must be allowed to do so at another time.

**End-of-Term Tests and Assignments.** For each subject with a final examination, no test should be given and no assignment, term paper, or oral presentation should fall due after the Friday preceding the start of the Reading Period.

For each subject without a final examination, at most, either one in-class test may be given, or one assignment, term paper, or oral presentation may fall due between the Friday preceding the start of the Reading Period and the end of the last regularly scheduled class in the subject. An in-class test given during this period is limited to one normal class period (or to one and one-half hours, whichever is shorter).

**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://web.mit.edu/registrar/classrooms/exams-finals/index.html](http://web.mit.edu/registrar/classrooms/exams-finals/index.html) 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. The SNOW line (617-253-SNOW) refers callers to 617-258-TEST for exam information.
- 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://web.mit.edu/registrar/classrooms/exams-finals/index.html](http://web.mit.edu/registrar/classrooms/exams-finals/index.html).
- 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/](http://web.mit.edu/registrar/) 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 of 3.0 or above (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 Academic Guide for Undergraduates and Their Advisors gives more detailed information concerning the end-of-term procedures followed by the CAP in reviewing the academic records of undergraduate students. Published by the CAP and the Office of Faculty Support, this resource is available at the following website: http://web.mit.edu/acadinfo/undergrad/academic-guide/. For further information, contact the CAP Office, Room 7-104, 617-253-4164, or visit http://web.mit.edu/acadinfo/cap/.

In order to receive federal financial aid under Title IV, an undergraduate student is considered to be making satisfactory progress as long as at least 33 units per term have been completed with a term rating above 3.0 at the end of any regular term. 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 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 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 10 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://web.mit.edu/odge/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 functions, 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 satisfy 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.
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 awarded during and after fall 1996-1997 must be resolved prior to graduation.

Notation assigned for work such as thesis, UROP, Special Topics, 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. Unless a student’s progress improves significantly, the student may expect that grade to be failing.

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.

DR Notation used only on the student’s internal record for a subject dropped after the fifth week of the regular term.

LIS Notation used only on the student’s internal record for a subject the student registered for as a listener.

URN Notation for a subject in UROP taken for pay or as a volunteer rather than academic credit.

VIS Notation for a research subject taken as a non-degree visiting student.
Parting environment requires that all members of the community exercise due
necessary for the department head to review, or otherwise to assist in, the
the faculty member and the students involved. In some cases, it may be
information on Term Regulations earlier in this section.

Academic dishonesty are considered serious offenses for which disciplinary
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 learn-
ing environment requires that all members of the community exercise due
respect for the basic rights of one another.

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-
tion 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 consti-
tute 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 responsibil-
ity 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 poli-
cy 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://

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 acknowledgement 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.

We expect that members of the MIT 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 our responsibility to consider the well-being of 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 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 compo-

nents meant to address the wrongdoing and serve the larger community. Detailed procedures are available at 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/, 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 address, 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 athletic 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
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 misleading. 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 record the student wants changed, and state why it is inaccurate or misleading. 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 requirements 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
<table>
<thead>
<tr>
<th>School of Architecture and Planning</th>
<th>82</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture</td>
<td>85</td>
</tr>
<tr>
<td>Media Arts and Sciences</td>
<td>92</td>
</tr>
<tr>
<td>Urban Studies and Planning</td>
<td>94</td>
</tr>
<tr>
<td><strong>School of Engineering</strong></td>
<td>101</td>
</tr>
<tr>
<td>Aeronautics and Astronautics</td>
<td>106</td>
</tr>
<tr>
<td>Biological Engineering</td>
<td>118</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>124</td>
</tr>
<tr>
<td>Civil and Environmental Engineering</td>
<td>133</td>
</tr>
<tr>
<td>Electrical Engineering and Computer Science</td>
<td>143</td>
</tr>
<tr>
<td>Engineering Systems</td>
<td>153</td>
</tr>
<tr>
<td>Materials Science and Engineering</td>
<td>160</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>169</td>
</tr>
<tr>
<td>Nuclear Science and Engineering</td>
<td>183</td>
</tr>
<tr>
<td><strong>School of Humanities, Arts, and Social Sciences</strong></td>
<td>189</td>
</tr>
<tr>
<td>Anthropology</td>
<td>192</td>
</tr>
<tr>
<td>Comparative Media Studies</td>
<td>194</td>
</tr>
<tr>
<td>Economics</td>
<td>197</td>
</tr>
<tr>
<td>Foreign Languages and Literatures</td>
<td>201</td>
</tr>
<tr>
<td>History</td>
<td>205</td>
</tr>
<tr>
<td>Humanities</td>
<td>207</td>
</tr>
<tr>
<td>Linguistics and Philosophy</td>
<td>210</td>
</tr>
<tr>
<td>Literature</td>
<td>214</td>
</tr>
<tr>
<td>Music and Theater Arts</td>
<td>216</td>
</tr>
<tr>
<td>Political Science</td>
<td>219</td>
</tr>
<tr>
<td>Science, Technology, and Society</td>
<td>222</td>
</tr>
<tr>
<td>Writing and Humanistic Studies</td>
<td>225</td>
</tr>
<tr>
<td><strong>MIT Sloan School of Management</strong></td>
<td>228</td>
</tr>
<tr>
<td>Management</td>
<td>231</td>
</tr>
<tr>
<td><strong>School of Science</strong></td>
<td>239</td>
</tr>
<tr>
<td>Biology</td>
<td>242</td>
</tr>
<tr>
<td>Brain and Cognitive Sciences</td>
<td>247</td>
</tr>
<tr>
<td>Chemistry</td>
<td>253</td>
</tr>
<tr>
<td>Earth, Atmospheric, and Planetary Sciences</td>
<td>257</td>
</tr>
<tr>
<td>Mathematics</td>
<td>263</td>
</tr>
<tr>
<td>Physics</td>
<td>268</td>
</tr>
</tbody>
</table>
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 Laboratory, the Center for Real Estate, and the Center for Advanced Visual Studies.

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 students a year in an array 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—designed by Fumihiko Maki, winner of the Pritzker Prize in 1993—is currently under construction. Adjacent to and part of the School’s legendary Media Lab, designed by alumnus I. M. Pei (1940 BArch), the facility will also house a diverse array of teaching and research efforts now going on in other divisions of the School.

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.

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 a thriving fellowship program, 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; Rotch Visual Collections, an adjacent branch library, holds 350,000 visual images, including the Aga Khan Visual Archive.

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 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 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 array of publications.
### Degrees Offered in the School of Architecture and Planning

<table>
<thead>
<tr>
<th>Architecture</th>
<th>Course 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB</td>
<td>Art and Design (BSAD)</td>
</tr>
<tr>
<td>SB</td>
<td>Architecture Studies</td>
</tr>
<tr>
<td>MArch</td>
<td>Architecture Studies</td>
</tr>
<tr>
<td>SMBT</td>
<td>Building Technology</td>
</tr>
<tr>
<td>SMVisS</td>
<td>Visual Studies</td>
</tr>
<tr>
<td>PhD</td>
<td>Architecture: Building Technology</td>
</tr>
<tr>
<td>PhD</td>
<td>Architecture: Design and Computation</td>
</tr>
<tr>
<td>PhD</td>
<td>Architecture: History and Theory of Architecture</td>
</tr>
<tr>
<td>PhD</td>
<td>Architecture: History and Theory of Art</td>
</tr>
<tr>
<td>Dual Degrees</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Media Arts and Sciences</th>
<th>Course MAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>Media Technology</td>
</tr>
<tr>
<td>SM</td>
<td>Media Arts and Sciences</td>
</tr>
<tr>
<td>PhD</td>
<td>Media Arts and Sciences</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Urban Studies and Planning</th>
<th>Course 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB</td>
<td>City Planning</td>
</tr>
<tr>
<td>MCP</td>
<td>Urban Studies and Planning</td>
</tr>
<tr>
<td>SM</td>
<td>Urban and Regional Planning</td>
</tr>
<tr>
<td>PhD</td>
<td>Urban and Regional Studies</td>
</tr>
<tr>
<td>PhD</td>
<td>Urban and Regional Studies</td>
</tr>
<tr>
<td>Dual Degrees</td>
<td></td>
</tr>
<tr>
<td>Certificates</td>
<td>Urban Design, Environmental Planning</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Center for Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSRED</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.
The Department of Architecture conceives of architecture as a discipline as well as a profession. Five semi-autonomous, graduate degree-granting “discipline groups” provide an architectural education that is as complex as the field itself. Each discipline group is supported by the other four, and all five contribute to a mutual enterprise. Students learn ways of working that draw upon the whole range of resources that architecture affords in finding and defining the expansive problems of building, as well as in proposing effective solutions. The groups are Architectural Design; Building Technology; Computation; History, Theory and Criticism of Architecture and Art (HTC); and Visual Arts Program (VAP).

In the several disciplines of the department, there is a substantial body of 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, and energy as well as in the arts and humanities. The department builds on, and contributes to, such valuable institutional commitments.

The department offers six degree programs: the Bachelor of Science in Art and Design, Master of Architecture, Master of Science in Architecture Studies, Master of Science in Building Technology, Master of Science in Visual Studies, and the Doctor of Philosophy.

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 Philosophy.

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 Philosophy.

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 Philosophy.

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 Philosophy.

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 Philosophy.

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 Philosophy.

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 Philosophy.
in-depth, agenda-setting research and teaching. Topics taught cover the description, generation, and construction of architectural and urban form and other designed artifacts using computational means, including computer visualization and modeling; generative theories, strategies, and 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 to undergraduates in Course 4 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 discipline areas as a means to explore and develop their interests.

The History, Theory, and Criticism of Architecture and Art group teaches subjects dealing with the history of art and architecture. Offerings range in content and method. Some study questions internal to the discipline of architecture, while others seek contexts in social, political, and intellectual history. Some are motivated by questions derived from the problems of contemporary practice. Others take their organization from a body of historical material investigated in ways that develop skills of analysis applicable to a wide range of topics. The group teaches subjects from the Renaissance forward in time, focusing on materials that are both abstract and concrete, with scales that range from the architectural drawing to the urban environment. There is a special emphasis on topics of modern art and architecture.

HTC offers a concentration to undergraduates in Course 4 and a HASS concentration and minor in the history of architecture to all MIT undergraduates. There is a doctoral program with emphasis on the history, theory, and criticism of art and architecture, and students in the Master of Science in Architecture Studies program may choose to concentrate in HTC.

The Visual Arts Program offers a diverse range of subjects in studio practice and operates as a critical production and education-based laboratory within the context of an advanced technological community. Students explore
the role of art in society and consider artistic practice as knowledge production. Studio investigations and artistic research are realized through performance, sound and video, photography, and interrogative design as well as through experimental media and new genres. The program also emphasizes art that engages public spheres, the production of space, 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.

This area of study offers a concentration to undergraduates in Course 4 and a HASS concentration in the visual arts to all undergraduates. It also offers a graduate major leading to a Master of Science in Visual Studies. Undergraduate and graduate subjects are also offered to students from other disciplines who would like to experience contemporary arts practice.

More information about the Department of Architecture and its programs can be found at http://architecture.mit.edu/ and http://visualarts.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 Art and Design, and Course 4-B leads to the Bachelor of Science.

Bachelor of Science in Art and Design/ Course 4

Course 4 offers a flexible program for students in five possible discipline streams: visual arts; architectural design; building technology; 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 Art and Design (BSAD) curriculum begin with an introductory subject, 4.111 Experiencing Architecture Studio, designed to be taken by freshmen and sophomores. The remaining core subjects include beginning work in the arts, computation, architectural design, building technology, and the history of architecture and art.

The department has a handout (also available on its website) that gives subject requirements for each of its five discipline streams. 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 discipline stream at the end of their sophomore year.

The majority of BSAD 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. The design studio is a place not only where technical and analytical skills are developed, but a place of synthesis and invention using the elements of architectural form: material, structure, construction, light, sound, memory, and place. This is the process that characterizes the architectural education and what the studio sequence explores.

Students who plan to continue their studies for the graduate degree in architecture must apply for admission to the Master of Architecture (MArch) program. Students who have fulfilled the requirements for the Architectural Design discipline stream of the Bachelor of Science in Art and Design may be able to satisfy the requirements for the MArch in two and one-half years rather than three and one-half if they include a sufficient number of professional subjects in their undergraduate program. This requires careful use of a student’s unrestricted electives.

Students who intend to continue with graduate studies in the visual arts, building technology, and history, theory, and criticism of architecture and art should consult with an appropriate faculty member to design a program of study that establishes the basis for graduate study.

Notes

* Alternate prerequisites are listed in the subject description.

** Only three subjects required by the department may also satisfy the General Institute Requirements. Students in the Visual Arts departmental discipline stream may not have a HASS concentration in Visual Arts; nor may History, Theory, and Criticism of Architecture and Art discipline stream students concentrate in the HASS field of History of Art and Architecture.

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 department offers a foreign exchange study program with Delft University of Technology and Hong Kong University for architecture design seniors in the fall term. A required senior thesis is taken in the final year in all of the discipline streams except for architecture design, for which it is optional.

Bachelor of Science/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 architecture with subjects in urban studies and planning, comparative media studies, systems analysis, acoustics, 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 that the six core subjects that are to be taken primarily in the freshman and sophomore years are 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.THT Thesis Research Design Seminar, is required.

Minors
The requirements for a Minor in Architecture are as follows:

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.111</td>
<td>Experiencing Architecture Studio</td>
</tr>
<tr>
<td>4.112</td>
<td>Integrated Architecture Design Studio</td>
</tr>
</tbody>
</table>
| 4.605    | Introduction to the History and Theory of Architecture and either
| 4.113    | Applied Architecture Design Studio I
| 4.114    | Applied Architecture Design Studio II or
| 4.614    | Religious Architecture and Islamic Cultures

The Minor in the History of Art and Architecture, considered a HASS minor, is designed to enable students to concentrate on the historical, theoretical, and critical issues associated with artistic and architectural production. Introductions to the historical framework and stylistic conventions of art and architectural history are followed by more concentrated study of particular periods and theoretical problems in visual culture and in cultural history in general.

The minor consists of six subjects arranged into three levels of study and chosen as follows:

- **Tier I**
  - Two subjects:
    - 4.601 Introduction to Art History or
    - 4.602 Modern Art and Mass Culture and
    - 4.605 Introduction to the History and Theory of Architecture or
    - 4.614 Religious Architecture and Islamic Cultures

- **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:
    - 4.613 Civic Architecture in Islamic History
    - 4.635 Renaissance Architecture
    - 4.641 19th-Century Art

- **Tier III**
  - One subject:
    - 4.609 Seminar in the History of Art and Architecture or
    - Other advanced seminar in the history of art and/or architecture with permission of the HASS field advisor.

For a general description of minors, see Undergraduate Education in Part 1.

GRADUATE STUDY
The Department of Architecture offers five graduate degree programs—the Master of Architecture, Master of Science in Architecture Studies, Master of Science in Building Technology, Master of Science in Visual Studies, and the Doctor of Philosophy.

The Master of Architecture is awarded to students who complete a program, accredited by the National Architectural Accrediting Board, that is an essential step toward licensure for architectural practice.

The Master of Science in Architecture Studies program stresses research and inquiry in the built environment; the degree is meant for students who already have their first professional architecture degree and those whose previous education orient 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. It is meant for students who intend to make a career in this field.

The Master of Science in Visual Studies focuses on the development of critical and visionary positions of artistic practice 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...
The professional MArch program is seen as being diverse and open-ended with many views of appropriate research and practice of architecture available, yet with a general set of shared concerns. These include a commitment to design, an interest in materials and technology, a concern for social and urban issues, an interest in inquiry and criticism, a view of the environment as a living and developing phenomenon, an interest in the relation between the built environment and institutions, a regard for the material processes of building, a perspective on new technologies and their impact on practice, and a concern for the spatial and temporal contexts of buildings. Given the varied perspectives from which the curriculum is conceived, an important aspect of the students’ development is to be able to establish links between different areas of focus and its many disciplines.

Architectural design studios are the center of the MArch degree program. Students must recognize that there are many possible professional roles, and therefore must assume much of the responsibility for structuring their own educational programs. While the professional curriculum specifies that a student study a range of subjects in several interrelated fields, students in the MArch program have some choice within each of the study areas offered in the department, and are required to develop a concentration in a self-determined area.

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, of which 42 will be H-level subjects, and the completion of an acceptable thesis. The degree requires two full academic years of residency.

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.

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 urbanism.

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 preservation, and the critique of contemporary design in Islamic countries.

The mission of Design and Computation is to promote a rethinking of technique in relation to architectural design and its production, as well as to challenge conventional distinctions between physical and virtual environments. Research focuses on new means for describing, representing, and generating architectural design; for modeling physical processes; and for fabrication.
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 which 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, 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 Visual Studies

The Visual Arts Program aims to develop artists and cultural producers with diverse backgrounds and experience interested in innovative, artistic practice and research at the intersection of art, culture, science, and technology. It offers a wealth of transdisciplinary research opportunities. Central to the SMVisS curriculum is the potential for links with programs in architecture, urbanism, technology, and media studies. It offers an academic research setting and studio environment for innovative, experimental, and critical artistic production. Areas of investigation include media art, networked cultures, expanded video and photography as well as performance, interrogative design, and art in the public sphere. Students are challenged to explore the role of art in society and to expand their practice through an informed and articulate focus on the cultural, social, and ethical implications of individual and collective projects. Regular SMVisS tutorials foster in-depth examination of student work in progress.

The SMVisS degree is completed in two years, requires 156 units of coursework (123 of which must be H-level graduate credit), and the completion of an acceptable thesis.

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 the area of History, Theory, and Criticism of Architecture and Art emphasizes the study of Western (19th and 20th centuries) and Islamic art, architecture and urbanism, and methodological issues that inform or link historical and practical work.

The doctoral program in Building Technology is interdepartmental, with important components in the departments of Civil and Environmental Engineering, Electrical Engineering and Computer Science, and Mechanical Engineering. 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 work spaces. 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 for the PhD 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/.
Caroline Jones, PhD
Professor of the History of Art
(On leave)

Sheila Kennedy, MArch
Professor of the Practice of Architecture

Terry Knight, PhD
Professor of Design and Computation

Rahul Mehrotra, MAUD
Professor of Architecture

Terry Knight, PhD
Professor of Design and Computation

John Fernandez, MArch
Associate Professor of Architecture and Building Technology

David Hodes Friedman, PhD
Associate Professor of the History of Architecture

Mark Goulthorpe, BArch
Associate Professor of Design

Takehiko Nagakura, MArch, PhD
Associate Professor of Design and Computation

John Ochsendorf, PhD
Associate Professor of Building Technology

Lawrence Sass, PhD
Associate Professor of Computation and Design

Andrew Scott, BArch
Associate Professor of Architecture
(On leave, fall)

Dennis Shelden, PhD
Associate Professor of the Practice of Computation (Spring)

Gediminas Urbonas, MFA
Associate Professor of Visual Arts

J. Meejin Yoon, MAUD
Associate Professor of Architecture

Assistant Professors

Ana Milijacki, MArch, PhD
Associate Professor of Architecture

William O’Brien, Jr.
Assistant Professor of Architecture

Kristel Smentek, PhD
Assistant Professor of the History of Art

Visiting Professor

Antonio Muntadas, MA (Spring)

Senior Lecturer

Shun Kanda, BArch, MArch (Spring)

Lecturers

Dan Chen, MArch (Fall)

Andrea Frank, MFA

Amber Frid-Jimenez, MS (Fall)

Joe Gibbons, MFA

Bill Hubbard, Jr., MAAS

Wendy Jacob, MFA

Joel Lamere, MArch

Miho Mazereeuw, MArch, MLA (Fall)

Nondita Correa Mehrotra, MArch

Corinne Ulmann, MArch (Fall)

Angela Watson, MArch (Fall)

Joseph Zane, MFA (Fall)

Technical Instructor

Christopher Dewart, BA

Research Staff

Principal Research Associate

Reinhard Goethert, MArch, PhD

Principal Research Scientist

Kent Larson, BArch

Research Scientist

Stephen Intille, PhD

Professors Emeriti

Wayne V. Andersen, PhD
Professor of the History of Art, Emeritus

Eduardo Fernando Catalano, MArch
Professor of Architecture, Emeritus

John de Monchaux, MArch
Professor of Architecture and Urban Studies, Emeritus

Eric Dluhosch, MArch, PhD
Professor of Building Technology, Emeritus

Leon Bennett Groisser, ScD
Professor of Structures, Emeritus

N. John Habraken, BI
Professor of Architecture, Emeritus

Edward Levine, MA, PhD
Professor of Visual Arts, Emeritus

John Randolph Myer, BArch
Professor of Architecture, Emeritus

Otto Piene, MA
Professor of Architecture, Emeritus

William Lyman Porter, MArch, PhD
Professor of Architecture, Emeritus

Maurice Keith Smith, BArch
Professor of Architecture, Emeritus

Chester Lee Sprague, MArch
Associate Professor of Architecture, Emeritus

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, \url{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 courses 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, \url{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 this program 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 Aaron Solle, Room E15-401, 617-253-5114, fax 617-253-8542, mas@media.mit.edu.

**FACULTY AND STAFF**

**Faculty and Teaching Staff**

Mitchel Resnick, PhD
Professor of Media Arts and Sciences
LEG0 Papert Career Development Professor of Learning Research
Program Head

Patricia Maes, PhD
Associate Professor of Media Technology
Associate Program Head

**Professors**

Neil Gershenfeld, PhD
Professor of Media Arts and Sciences

Hiroshi Ishii, PhD
Muriel R. Cooper Career Development Professor of Media Arts and Sciences

Tod Machover, MM
Professor of Music and Media

John Maeda, PhD
Professor of Design and Computation
(On leave)

William J. Mitchell, BArch, MEDES, MA
Professor of Architecture and Media Arts and Sciences

Alexander W. Dreyfous, Jr. (1954) Professor of Media Arts and Sciences

Nicholas Negroponte, MArch
Professor of Media Technology
(On leave)

Alex Pentland, PhD
Toshiba Professor of Media Arts and Sciences

Rosalind Picard, ScD
Professor of Media Arts and Sciences

Barry Vercoe, DMA
Professor of Media Arts and Sciences

**Associate Professors**

Cynthia Breazeal, ScD
LG Career Development Associate Professor of Media Arts and Sciences

Hugh Herr, PhD
Associate Professor of Media Arts and Sciences

Ramesh Raskar, PhD
NEC Career Development Associate Professor of Media Arts and Sciences

Deb Roy, PhD
NEC Career Development Associate Professor of Media Arts and Sciences

Joseph Paradiso, PhD
NEC Career Development Associate Professor of Media Arts and Sciences

John Maeda, PhD
Professor of Design and Computation
(On leave)

**Professors**

Neil Gershenfeld, PhD
Professor of Media Arts and Sciences

Hiroshi Ishii, PhD
Muriel R. Cooper Career Development Professor of Media Arts and Sciences

Tod Machover, MM
Professor of Music and Media

John Maeda, PhD
Professor of Design and Computation
(On leave)

William J. Mitchell, BArch, MEDES, MA
Professor of Architecture and Media Arts and Sciences

Alexander W. Dreyfous, Jr. (1954) Professor of Media Arts and Sciences

Nicholas Negroponte, MArch
Professor of Media Technology
(On leave)

Alex Pentland, PhD
Toshiba Professor of Media Arts and Sciences

Rosalind Picard, ScD
Professor of Media Arts and Sciences

Barry Vercoe, DMA
Professor of Media Arts and Sciences

**Associate Professors**

Cynthia Breazeal, ScD
LG Career Development Associate Professor of Media Arts and Sciences

Hugh Herr, PhD
Associate Professor of Media Arts and Sciences

Ramesh Raskar, PhD
NEC Career Development Associate Professor of Media Arts and Sciences

Deb Roy, PhD
NEC Career Development Associate Professor of Media Arts and Sciences

Joseph Paradiso, PhD
NEC Career Development Associate Professor of Media Arts and Sciences

John Maeda, PhD
Professor of Design and Computation
(On leave)

**Professors**

Neil Gershenfeld, PhD
Professor of Media Arts and Sciences

Hiroshi Ishii, PhD
Muriel R. Cooper Career Development Professor of Media Arts and Sciences

Tod Machover, MM
Professor of Music and Media

John Maeda, PhD
Professor of Design and Computation
(On leave)

William J. Mitchell, BArch, MEDES, MA
Professor of Architecture and Media Arts and Sciences

Alexander W. Dreyfous, Jr. (1954) Professor of Media Arts and Sciences

Nicholas Negroponte, MArch
Professor of Media Technology
(On leave)

Alex Pentland, PhD
Toshiba Professor of Media Arts and Sciences

Rosalind Picard, ScD
Professor of Media Arts and Sciences

Barry Vercoe, DMA
Professor of Media Arts and Sciences

**Associate Professors**

Cynthia Breazeal, ScD
LG Career Development Associate Professor of Media Arts and Sciences

Hugh Herr, PhD
Associate Professor of Media Arts and Sciences

Ramesh Raskar, PhD
NEC Career Development Associate Professor of Media Arts and Sciences

Deb Roy, PhD
NEC Career Development Associate Professor of Media Arts and Sciences

Joseph Paradiso, PhD
NEC Career Development Associate Professor of Media Arts and Sciences

John Maeda, PhD
Professor of Design and Computation
(On leave)
David Small, PhD
Associate Professor of Media Arts and Sciences
Asahi Broadcasting Corporation Career Development Associate Professor of Research in Education

Assistant Professors
Edward S. Boyden III, PhD
Assistant Professor of Media Arts and Sciences
Benesse Career Development Assistant Professor of Research and Education
Leah Beuchley, PhD
Assistant Professor of Media Arts and Sciences

Research Staff

Senior Research Scientists
Walter Bender, MSVS (On leave)
Andrew Lippman, PhD

Professors Emeriti
Marvin Minsky, PhD
Professor of Media Arts and Sciences, Emeritus
Seymour Papert, PhD
Professor of Education and Media Technology, 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 (usually reserved for mid-career students); and a PhD in Urban Studies and Planning. In addition, DUSP has three kinds of nondegree programs and affiliations; the Special Program in Urban and Regional Studies (for mid-career professionals from developing countries); the Community Innovators Lab (which engages mid-career professionals from communities of color in the United States and beyond); and the SENSEable City Lab, a research center concerned with the relationship between technology and cities. DUSP also offers special-student status for part-time mid-career professionals interested in taking individual subjects. 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 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 must 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; 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 limited to those undergraduates who have demonstrated exceptional professional promise. Students can obtain more information on the five-year program from Sandra Wellford, 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 government, 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. When undergraduate electives are unavailable in the student’s field of interest, the student may choose from a variety of graduate courses, subject to the instructor’s permission. Finally, students take 11.123 Big Plans, 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 minor program requirements and in consultation with the minor advisor.

**Bachelor of Science in Planning/Course 11**

**General Institute Requirements (GiRs)**

<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 [four 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 [can be satisfied by 11.188 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: 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>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Subjects</td>
</tr>
<tr>
<td>11.001 Introduction to Urban Design and Development, 12, HASS</td>
</tr>
<tr>
<td>11.002J Making Public Policy, 12, HASS-D, CI-H</td>
</tr>
<tr>
<td>11.123 Big Plans, 9, HASS</td>
</tr>
<tr>
<td>14.01 Principles of Microeconomics, 12, HASS</td>
</tr>
<tr>
<td>11.188 Urban Planning and Social Science Laboratory, 12, LAB, CI-M; permission of instructor</td>
</tr>
</tbody>
</table>

Planned Electives 57

Majors in Course 11 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.

**Urban and Environmental Policy and Planning**

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.011 The Art and Science of Negotiation, 12, HASS</td>
</tr>
<tr>
<td>11.014J American Urban History II, 9, HASS</td>
</tr>
<tr>
<td>11.016J The Once and Future City, 12, HASS, CI-H</td>
</tr>
<tr>
<td>11.026J Downtown, 9, HASS</td>
</tr>
<tr>
<td>11.122 Society and Environment, 12, HASS</td>
</tr>
<tr>
<td>1.011 Project Evaluation, 9</td>
</tr>
<tr>
<td>1.041J Engineering System Design, 12; 1.011*</td>
</tr>
</tbody>
</table>

**Urban Society, History, and Politics**

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.013J American Urban History I, 9, HASS</td>
</tr>
<tr>
<td>11.014J American Urban History II, 9, HASS</td>
</tr>
<tr>
<td>11.05J Riots, Strikes, and Conspiracies in American History, 12, HASS-D, CI-H</td>
</tr>
<tr>
<td>11.020 Poverty, Public Policy, and Controversy, 12, HASS</td>
</tr>
<tr>
<td>11.023 Bridging Cultural and Racial Differences, 12, HASS</td>
</tr>
<tr>
<td>11.024 Great Cities, 9, HASS</td>
</tr>
<tr>
<td>11.026J Downtown, 9, HASS</td>
</tr>
<tr>
<td>11.330J Theory of City Form, units arranged; 11.001J*</td>
</tr>
</tbody>
</table>

**Urban and Regional Public Policy**

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.003J Methods of Public Policy Analysis, 12, HASS; 11.002J, 17.30J, 14.01</td>
</tr>
<tr>
<td>11.005 Introduction to International Development, 12</td>
</tr>
<tr>
<td>11.011 The Art and Science of Negotiation, 12, HASS</td>
</tr>
<tr>
<td>11.020 Poverty, Public Policy, and Controversy, 12, HASS</td>
</tr>
<tr>
<td>11.025 D-Lab: Development, 12; permission of instructor</td>
</tr>
<tr>
<td>11.126J Economics of Education, 12, HASS; 14.01</td>
</tr>
<tr>
<td>11.166J Law, Social Movements, and Public Policy, 12, HASS; permission of instructor</td>
</tr>
</tbody>
</table>

**Urban Field Experience**

Declared majors are encouraged to take the optional urban field experience subject. 11.027 City to City (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.

**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.

11.ThT Thesis Research Design Seminar, 12, CI-M

Part 96

To explore a particular policy problem. Six areas are competence within a specific discipline or to clusters allow students either to develop the Institute requirement. These three-subject DUSP offers clusters of subjects that satisfy HASS Concentrations.

A detailed description and list of requirements for this minor can be found in the Interdisciplinary HASS Minor in Public Policy. 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 11.124 and 11.125. More information is available from Eric Klopfer, Room 10-337, 617-253-2025.

Notes

* Alternate prerequisites and corequisites are listed in the subject description.

Course 11 majors are not permitted to have a HASS concentration in Urban Studies.

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.

11.013J American Urban History I
11.014J American Urban History II
11.016J The Once and Future City
11.020 Poverty, Public Policy, and Controversy
11.023 Bridging Cultural and Racial Differences
11.024 Great Cities
11.025 D-Lab: Development
11.026J Downtown
11.102J Theories of Economic Development
11.122J Society and Environment
11.126J Economics of Education
11.166 Law, Social Movements, and Public Policy

Tier III

11.123J Big Plans

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. Course 11 majors are not eligible for the public policy minor. A detailed description and list of requirements for this minor can be found in the Interdisciplinary Undergraduate Programs and Minor section in Part 3. Students can obtain additional information from Sandra Wellford, undergraduate administrator, Room 7-346A, 617-253-9403.

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. Six areas are suggested: designing the urban environment, environmental policy, urban history, policy analysis and urban problems, legal issues and social change, and education. Sample programs are available from Sandra Wellford, undergraduate administrator, Room 7-346A, 617-253-9403.

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 10-337, 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

Students can test out of all except 11.201 and 11.202.

- 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 group is concerned with shaping the built and natural environment of cities and suburbs. Graduates work in a variety of private, public, and nonprofit roles: as urban designers, developers, planning and design consultants, municipal and regional planners, managers of public agencies to improve the environment, advocates of historic preservation and public art, and planners of transportation systems. The group is closely associated with faculty and students in the Department of Architecture and the Center for Real Estate, and many subjects are cross-listed with these programs. While the educational offerings are diverse and every student can develop unique competence in the area, there are at least three clusters of skills in city design and development: urban design, for those who wish to be involved in shaping the public realm; land use planning, for those who wish to work as municipal planners or consultants, or wish to be involved in planning large-scale development projects in the United States and abroad; and urban development, for those who wish to manage development projects for private companies or public sector organizations.

The Environmental Policy and Planning group emphasizes the study of the ways in which society conserves and manages its environmental resources. Areas of concern include the role of science in environmental policy making: climate change, sustainable development and 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 examine the interactions between built and natural systems: techniques for describing, modeling, 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, and national levels. IDG provides students with an integrated view of the institutional, historical, economic, technological, and socio-political 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; industrialization and industrial policies (including privatization); poverty-reducing and employment-increasing interventions, including informal sector, nongovernment organizations, and small enterprises; community, urban, and metropolitan politics and policy; property rights, collective action, and common property issues (water, forestry, grazing, agriculture); human rights; 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 the EPP office, Room 9-334, 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 questions that no single academic discipline can answer. Examples include the role of institutions in economic development and the rapid diffusion of information and communication technologies into urban planning and design. Students work under the mentorship of a faculty advisor. They may center their activities on any subfield 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: a broad intellectual discipline (city design and development, international development economics, public policy, planning information systems, urban and regional 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.

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 framing and solving today’s most urgent social problems.

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 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/), by emailing ruhfel@mit.edu, or calling 617-253-3216.

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 urban and regional 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/).

### FACULTY AND STAFF

**Faculty and Teaching Staff**

Amy Glasmeier, PhD
Professor of Geography and Regional Planning
Department Head

**Professors**

Alice H. Amsden, PhD
Barton L. Weller Professor of Political Economy

Brian A. Ciochetti, PhD
Professor of the Practice of Real Estate

Thomas G. Eastman Chair
Chairman and Director, Center for Real Estate

Phillip Clay, PhD
Professor of Urban Studies and Planning

Chancellor

Diane E. Davis, PhD
Professor of Political Sociology

(On leave)

Joseph Ferreira, Jr., PhD
Professor of Urban Planning and Operations Research

Chair, Master in City Planning Program

Robert M. Fogelson, PhD
Professor of Urban Studies and History

Dennis Frenchman, MCP, MArch

Norman B. and Muriel Leventhal Professor of Urban Design

David Geltner, PhD
George Macomber Professor of Real Estate Finance

Director or Research, Center for Real Estate

Frank Levy, PhD
Daniel Rose Professor of Urban Economics

Ceser McDowell, MEd, EdD
Professor of the Practice of Community Development

Karen R. Polenske, PhD
DeFlorez Professor of Regional Political Economy and Planning

Bishwapriya Sanyal, MCP, PhD
Ford International Professor of Urban and Regional Planning

Director, Special Program for Urban and Regional Studies in Developing Countries

Anne Spirm, MLA
Professor of Landscape Architecture and Planning

Lawrence E. Susskind, MCP, PhD
Ford Professor of Urban and Environmental Planning

Judith Tendler, PhD
Professor of Political Economy

Lawrence Vale, SMArchS, DPhil
Ford Professor of Urban Design and Planning

(On leave, fall)

William C. Wheaton, PhD
Professor of Urban Economics

**Associate Professors**

Eran Ben-Joseph, PhD
Associate Professor of Landscape Architecture and Planning

Chair, PhD Program

(On leave, fall)

Alan Berger, MLA
Associate Professor of Urban Design and Landscape Architecture

JoAnn Carmin, PhD
Associate Professor of Environmental Policy and Planning

Acting Chair, PhD Program (fall)
Senior Lecturer
Karl Seidman, MPP

Lecturers
Cherie Abbanat, MCP
David Fairman, PhD
Ezra Glenn, MA, AICP
Christopher Gordon, MS
YuHing Hong, PhD
John Kennedy, MS
W. Tod McGrath, MBA
Harvey Michaels, MCP
James Pennington, MSRED
Jonathan Raab, PhD
Gloria Schuck, PhD
Susan Silberberg-Robinson, MCP
Yanni Tsipis, MS

Principal Research Scientists
Christie Baxter, PhD
Thomas Piper, MArch

Visiting Faculty and Scholars
Steward Pickett, PhD
MLK Visiting Scholar
Manuel Castells, PhD
Distinguished Visiting Professor of Sociology and Planning
Herman Karl, PhD
Visiting Lecturer
Donyun Kim, PhD
Visiting Associate Professor
Sam Bass Warner, PhD
Visiting Professor of Urban History

Professors Emeriti
John de Monchaux, MArch
Professor of Architecture and Planning, Emeritus
Bernard J. Frieden, MCP, PhD
Ford Professor of Urban Development, Emeritus
Ralph Gakenheimer, MRP, PhD
Professor of Urban Planning, Emeritus
Gary Hack, MArch, MUP, PhD
Professor of Urban Design, Emeritus
Frank Jones, MBA
Ford Professor of Urban Affairs, Emeritus
Langley C. Keyes, PhD
Ford Professor of City and Regional Planning, Emeritus
Melvin H. King, MEd
Director, Community Fellows Program, Emeritus
Tunney F. Lee, BArch
Professor of Architecture and Urban Studies and Planning, Emeritus
Gary Marx, PhD
Professor of Sociology, Emeritus
Lisa Redfield Peatle, PhD
Professor of Urban Anthropology, Emerita
Senior Lecturer
Martin Rein, MSW, PhD
Professor of Social Policy, Emeritus
Clarence G. Williams, PhD
Adjunct Professor of Urban Studies and Planning, Emeritus

Assistant Professors
Michael Flaxman, PhD
Charles H. and Ann Spaulding Career Development Assistant Professor of Urban Technologies and Information Systems
Annette Kim, PhD
Ford Career Development Assistant Professor of Urban and Regional Planning
(On leave, spring)
P. Christopher Zegras, PhD
Ford Career Development Assistant Professor of Urban Planning and Transportation

Adjunct Professors
Richard Sennett, PhD
Bemis Adjunct Professor of Sociology and Urban Studies
Terry Szold, MRP
Adjunct Associate Professor of Land Use Planning

Adjunct Professors
Richard Sennett, PhD
Bemis Adjunct Professor of Sociology and Urban Studies
Terry Szold, MRP
Adjunct Associate Professor of Land Use Planning

Adjunct Professors
Richard Sennett, PhD
Bemis Adjunct Professor of Sociology and Urban Studies
Terry Szold, MRP
Adjunct Associate Professor of Land Use Planning
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, not only in the professional practice of engineering, but also in bringing the strengths of an engineering education to related fields such as law, medicine, management, and government. Never have the challenges and opportunities for careers in engineering been more exciting or more critical to the long-term well-being of society than they are today.

By creating, developing, organizing, and managing complex technologies and products, engineers 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 exciting endeavor. In a world increasingly influenced by scientific and technological innovation, engineers can provide important leadership to society.

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 the sophomore year and works closely with an advisor from that department or program. A student who would like to explore engineering as a major is encouraged to become involved with one of the engineering departments as early as the 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. Extracurricular clubs, such as the MIT Rocket Team or the Solar Electric Vehicle Team, offer students hands-on experiences.

Once a student chooses an undergraduate major, there are many opportunities for individual initiatives. For example, a significant number of students combine their primary undergraduate majors with a second undergraduate major in another area, such as management, political science, economics, one of the sciences, or another area of engineering. Others organize their programs so that they can receive 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; and pioneered the modern model of the research university, with externally sponsored research programs and a matrix of academic departments and research laboratories working across disciplines. MIT also created entire new fields, for example, chemical engineering, sanitary engineering, naval architecture and marine engineering, and the first course in aeronautical engineering. More recently, the School of Engineering has responded with new degree programs to the molecular and genomic revolutions that have made biology a foundational science for engineering.

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, formerly Leaders for Manufacturing (1988); System Design and Management (1997); the Deshpande Center for Technological Innovation and the Undergraduate Practice Opportunities Program (both in 2001); and the Bernard M. Gordon—MIT Engineering Leadership Program (2008).

The School of Engineering is constantly innovating in engineering education, developing novel pedagogical approaches, designing new subject offerings that strengthen current programs, and creating new disciplines, fields of study, majors, and graduate programs. Two examples are the SB in Chemical-Biological Engineering—MIT’s first undergraduate engineering degree with modern molecular biology as its core science; and, begun in 2005–2006, the SB in Biological Engineering. Five other new degree programs have been launched in the past five years: the SB in Mechanical and Ocean Engineering, MEng in Manufacturing, SM in Computation for Design and Optimization, PhD in Computational and Systems Biology, and PhD in Engineering Systems.

Because of its unique role in technological innovation, the School of Engineering is also the home of the Lemelson-MIT Program. Established in 1994, the program is an educational initiative whose mission is to recognize outstanding inventors as role models, encourage sustainable new solutions to real-world problems, and enable and inspire youth to pursue creative lives and careers through invention. It accomplishes this through annual awards, grants, and outreach activities, including the prestigious $500,000 Lemelson-MIT Prize, $100,000 Lemelson-MIT Award for Sustainability, and $30,000 Lemelson-MIT Student Prize. Lemelson-MIT InvenTeams is the program’s national initiative to inspire a new generation of inventors among high school students through grants that support a noncompetitive, team-based approach to learning and problem solving.

Today, six of the School’s departments are ranked at the top of their respective fields, and the others are ranked within the top five. Its eight academic departments and one division are home to 372 faculty members, slightly over one-third of the Institute’s total faculty. Among the most distinguished in the nation, nearly a third (117) 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 departmental descriptions and review 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 and divisions provide continuity and stability for the basic engineering disciplines, they increasingly share interests in the way their individual disciplines are applied. Interdepartmental centers, laboratories, and programs provide opportuni-
ties 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 that reside in the School of Engineering include the following:

- Center for Computational Engineering
- Center for Technology, Policy, and Industrial Development
- Center for Transportation and Logistics
- Computer Science and Artificial Intelligence Laboratory
- Deshpande Center for Technological Innovation
- Laboratory for Information and Decision Systems
- Laboratory for Manufacturing and Productivity
- Materials Processing Center
- Microsystems Technology Laboratories
- 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.

School-Wide Electives

The School of Engineering also offers a set of School-Wide Elective (SWE) subjects. An SWE subject may integrate knowledge from several disciplines and illustrate the commonality of the intellectual underpinnings of the departments in the School of Engineering. An SWE subject may also be the interface between an academic program in the School of Engineering and a program in another School at MIT; it may be a service subject to engineering students and other students; and it may be germane to many engineering students without being central to any one departmental program. Please note that registration for SWE subjects takes place through one of the departmental numbers. For complete subject descriptions and a list of the departmental numbers for each SWE subject, refer to the SWE subject listings in the online MIT Subject Listing & Schedule, [http://student.mit.edu/catalog/index.cgi](http://student.mit.edu/catalog/index.cgi).

**Undergraduate SWE subjects include the following:**
- Introduction to Modeling and Simulation
- Inventions and Patents
- Management in Engineering
- UPOP IAP Workshop
- UPOP Summer Practice Experience
- UPOP Reflective Learning Experience

**Graduate SWE subjects include:**
- Applications of Technology in Energy and the Environment (H-level graduate credit)
- Engineering Systems Analysis for Design (H-level graduate credit)
- Engineering Risk-Benefit Analysis (H-level graduate credit)
- Innovation Teams

**Undergraduate Practice Opportunities Program**

The Undergraduate Practice Opportunities Program (UPOP) is sponsored by the School of Engineering and administered by the Bernard M. Gordon–MIT Engineering Leadership Program. Open to all School of Engineering sophomores (on a first-come, first-served basis), this innovative program aims to provide engineering students with an opportunity to appreciate engineering practice outside the academic context through experiential learning that emphasizes the professional awareness, skills, and attitudes required to thrive in the world of engineering work.

UPOP has four components: an intensive one-week engineering practice workshop offered during IAP; extensive individual coaching and several pre-employment workshops taught during the sophomore fall and spring terms; 10 to 12 weeks of meaningful summer employment; and, in the following fall, a series of written and oral reflection exercises, including assessment interviews with staff members and roundtable meetings with other UPOP students, alumni, and faculty to reflect on the summer experience.

Additional information on the program can be obtained from Susann Luperfoy, executive director, Undergraduate Practice Opportunities Program, 617-253-0055, luperfoy@mit.edu, or [http://web.mit.edu/engineering/upop/](http://web.mit.edu/engineering/upop/).

**Office of the Dean**

Subra Suresh, ScD
Vannevar Bush Professor of Engineering
Professor of Materials Science and Engineering, Mechanical Engineering, and Biological Engineering
Affiliated Faculty, Harvard-MIT Division of Health Sciences and Technology
Dean

Cynthia Barnhart, PhD
Professor of Civil and Environmental Engineering
Codirector, Operations Research Center
Associate Dean for Academic Affairs

Karen Gleason, PhD
Alexander and I. Michael Kasser Professor of Chemical Engineering
Associate Dean for Research

Dedric Carter, PhD
Assistant Dean for Development and Strategic Initiatives

Eileen Ng-Ghavidel, MBA
Assistant Dean for Finance and Personnel

Donna R. Savicki, MA
Assistant Dean for Administration

Deborah Cohen, MS
Senior Development Officer

Chad Galts, MA
Director of Communications

Barbara Masi, PhD
Director of Education Innovation and Assessment
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

<table>
<thead>
<tr>
<th>Program</th>
<th>Course</th>
<th>Offerings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeronautics and Astronautics</td>
<td>Course</td>
<td>SM  Aeronautics and Astronautics</td>
</tr>
<tr>
<td>SB</td>
<td>16</td>
<td>Aerospace Engineering</td>
</tr>
<tr>
<td>SB</td>
<td></td>
<td>Aerospace Engineering with Information Technology</td>
</tr>
<tr>
<td>SM</td>
<td></td>
<td>Aeronautics and Astronautics</td>
</tr>
<tr>
<td>SM/MBA</td>
<td></td>
<td>Engineering/Management—dual degree with Leaders for Global Operations</td>
</tr>
<tr>
<td>Engineer</td>
<td></td>
<td>Aeronautics and Astronautics</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Aeronautics and Astronautics</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Aerospace Computational Engineering</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Air-Breathing Propulsion</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Aircraft Systems Engineering</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Air Transportation Systems</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Autonomous Systems</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Communications and Networks</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Controls</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Humans in Aerospace</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Materials and Structures</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Space Propulsion</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Space Systems</td>
</tr>
<tr>
<td>Biological Engineering</td>
<td>Course</td>
<td>SB  Biological Engineering</td>
</tr>
<tr>
<td>SB</td>
<td>20</td>
<td>Toxicology</td>
</tr>
<tr>
<td>SM/MBA</td>
<td></td>
<td>Engineering/Management—dual degree with Leaders for Global Operations</td>
</tr>
<tr>
<td>MEng</td>
<td></td>
<td>Biomedical Engineering</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Applied Biosciences</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Bioengineering</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Biological Engineering</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>Course</td>
<td>SB  Chemical Engineering</td>
</tr>
<tr>
<td>SB</td>
<td>10</td>
<td>Chemical-Biological Engineering</td>
</tr>
<tr>
<td>SB</td>
<td></td>
<td>Chemical Engineering</td>
</tr>
<tr>
<td>SM</td>
<td></td>
<td>Chemical Engineering Practice</td>
</tr>
<tr>
<td>SM/MBA</td>
<td></td>
<td>Engineering/Management—dual degree with Leaders for Global Operations</td>
</tr>
<tr>
<td>SM/MBA</td>
<td></td>
<td>Engineering/Management—dual degree with Leaders for Global Operations</td>
</tr>
<tr>
<td>MEng</td>
<td></td>
<td>Chemical Engineering</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Chemical Engineering Practice</td>
</tr>
<tr>
<td>PhD</td>
<td></td>
<td>Chemical Engineering Practice</td>
</tr>
<tr>
<td>Civil and Environmental Engineering</td>
<td>Course</td>
<td>SB  Civil Engineering</td>
</tr>
<tr>
<td>SB</td>
<td>1</td>
<td>Environmental Engineering Science</td>
</tr>
<tr>
<td>SM</td>
<td></td>
<td>Civil and Environmental Engineering</td>
</tr>
<tr>
<td>SM/MBA</td>
<td></td>
<td>Engineering/Management—dual degree with Leaders for Global Operations</td>
</tr>
<tr>
<td>SM/MBA</td>
<td></td>
<td>Engineering/Management—dual degree with Leaders for Global Operations</td>
</tr>
<tr>
<td>MEng</td>
<td></td>
<td>Civil and Environmental Engineering</td>
</tr>
<tr>
<td>Civil Engineer</td>
<td></td>
<td>Biological Oceanography (jointly with WHOI)</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Chemical Oceanography (jointly with WHOI)</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Civil and Environmental Engineering</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Civil and Environmental Systems</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Civil Engineering</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Coastal Engineering</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Construction Engineering and Management</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Environmental Biology</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Environmental Chemistry</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Environmental Engineering</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Environmental Fluid Mechanics</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Geotechnical and Geoenvironment Engineering</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Hydrology</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Information Technology</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Oceanographic Engineering (jointly with WHOI)</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Structures and Materials</td>
</tr>
<tr>
<td>PhD, ScD</td>
<td></td>
<td>Transportation</td>
</tr>
<tr>
<td>Computation for Design and Optimization</td>
<td></td>
<td>SM  Computation for Design and Optimization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10404</td>
</tr>
</tbody>
</table>

Part 2
<table>
<thead>
<tr>
<th>Course CSB</th>
<th>PhD</th>
<th>Computational and Systems Biology (jointly offered with the School of Science)</th>
</tr>
</thead>
</table>

| 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 |
| Engineer in Computer Science | ME ng | Electrical Engineering and Computer Science                                  |
|                     | PhD, ScD | Computer Science                                                           |
|                     | PhD, ScD | Electrical Engineering                                                      |
|                     | PhD, ScD | Electrical Engineering and Computer Science                                  |

| Course ESD          | SM  | Engineering and Management—jointly offered with the Sloan School of Management and Management Program |
|                     | SM  | Engineering Systems                                                         |
|                     | SM  | Technology and Policy                                                       |
|                     | SM/MBA | Engineering/Management—dual degree with Leaders for Global Operations Program |
|                     | ME ng | Logistics                                                                   |
|                     | PhD  | Engineering Systems                                                         |
|                     | PhD  | Technology, Management, and Policy                                           |

| Course 3            | SB  | Archaeology and Materials                                                  |
|                     | SB  | Materials Science and Engineering                                          |
|                     | SM  | Materials Science and Engineering                                          |
|                     | SM/MBA | Engineering/Management—dual degree with Leaders for Global Operations Program |
| Materials Engineer  | ME ng | Materials Science and Engineering                                          |
|                     | Metallurgical Engineer | Archaeological Materials                                                  |
|                     | PhD, ScD | Bio- and Polymeric Materials                                               |
|                     | PhD, ScD | Electronic, Photonic, and Magnetic Materials                               |
|                     | PhD, ScD | Emerging, Fundamental, and Computational Studies in Materials Science       |
|                     | PhD, ScD | Materials Science and Engineering                                          |
|                     | PhD, ScD | Structural and Environmental Materials                                      |

| Course 2            | SB  | Engineering                                                               |
|                     | SB  | Mechanical and Ocean Engineering                                         |
|                     | SB  | Mechanical Engineering                                                   |
|                     | SM  | Naval Architecture and Marine Engineering                                |
|                     | SM  | Ocean Engineering                                                        |
|                     | SM  | Oceanographic Engineering (jointly with WHOI)                            |
|                     | SM/MBA | Engineering/Management—dual degree with Leaders for Global Operations Program |
| Mechanical Engineer | ME ng | Manufacturing                                                              |
|                     | Naval Engineer | Mechanical Engineering                                                   |
|                     | PhD, ScD | Mechanical Engineering                                                   |
|                     | PhD, ScD | Naval Architecture and Marine Engineering                                |
|                     | PhD, ScD | Ocean Engineering                                                        |
|                     | PhD, ScD | Oceanographic Engineering (jointly with WHOI)                            |

| Course 22           | SB  | Nuclear Science and Engineering                                          |
|                     | SM  | Nuclear Science and Engineering                                          |

**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.
- See Interdisciplinary Graduate Programs section in Part 3.
The students, faculty, and staff in the Department of Aeronautics and Astronautics (Aero-Astro) 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 Aero-Astro 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, Aero-Astro 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. Aero-Astro’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.

Aero-Astro 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 Aero-Astro 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, Aero-Astro 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 architettcting, 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; multiscaling 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

Bachelor of Science in Aerospace Engineering/Course 16-1 or Aerospace Engineering with Information Technology/Course 16-2

Undergraduate study in the department leads to either the Bachelor of Science in Aerospace Engineering (Course 16-1) or the Bachelor of Science in Aerospace Engineering with Information Technology (Course 16-2) at the end of four years. The 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...
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 Aero-Astro curriculum. They also satisfy the Institute 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 subject sequences: 16.621 and 16.622 Experimental Projects I and II; or 16.821 Flight Vehicle Development; or 16.831 and 16.832 Space Systems Development I and II. These sequences satisfy the Institute Laboratory Requirement. In 16.821 and 16.831/16.832 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 ecology option of 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.

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.

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, please contact Marie Stuppard in the Aero-Astro Academic Programs Office, Room 33-208, 617-253-2279, mas@mit.edu.
Undergraduate Practice Opportunities Program
The Undergraduate Practice Opportunities Program (UPOP) 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. UPOP 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, please contact Barbara Lechner in the Aero-Astro Academic Programs Office, Room 33-208, 617-258-7243, blechner@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 also choose to 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, please contact Barbara Lechner in the Aero-Astro Academic Programs Office, Room 33-208, 617-258-7243, blechner@mit.edu.

Year Abroad Program
The department offers its undergraduate students an optional Year Abroad Program in partnership with several foreign schools of aeronautics and astronautics. Current partner schools are: Imperial College (London), L’Institut Supérieur de l’Aéronautique et de l’Espace (Toulouse, France), Escuela Técnica Superior de Ingenieros Aeronáuticos (ETSIA, Madrid, Spain), Royal Technical Institute of Sweden (KTH, Stockholm), University of Stuttgart (Germany), and the Swiss Federal Institute of Technology (ETH, Zurich). The department also participates in the Cambridge University-MIT Undergraduate Exchange (CME) program. 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 MIT students. For more information, contact Col. John Keesee (jkeesee@mit.edu) or 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, Holyoke Community College, Mount Holyoke College, Northeastern University, Olin College of Engineering, Roxbury Community College, Smith College, Tufts University, University of Massachusetts, Wellesley College, Williams College, Worcester College, Worcester Polytechnic Institute, Boston Museum of Science, the Marine Biological Laboratory, the Christa McAuliffe Center/Framingham College, 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 academies 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 33-208, 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, please 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, engineer’s, and doctoral levels. The range of subject matter is described in the section Sectors of Instruction; subjects are listed in the 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 250/600 to be considered for
admission to this department. TOEFL waivers are not accepted. No other exam fulfills 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:

1. 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.

2. 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.

3. 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 or two graduate-level mathematics subjects. The requirement is satisfied only by graduate-level subjects on the list approved by the department graduate committee. For students with a strong mathematical background, the requirement may be satisfied by taking one subject from the list of advanced math subjects approved by the graduate committee and by achieving a grade of B or better in the subject. The specific choice of math subjects is arranged individually by each student in consultation with their faculty advisor.

**Engineer in Aeronautics and Astronautics**

The program leading to the degree of Engineer in Aeronautics and Astronautics is offered on a very limited basis to current students who are interested in a greater breadth of graduate subjects than is normally associated with a master’s or doctoral program, with less emphasis on research than is required of doctoral candidates. The minimum study program of 162 subject units must include graduate subjects from each of the sectors, and the thesis work must have a strong engineering, as distinct from a scientific, orientation. Two years beyond the Bachelor of Science degree normally are the minimum for completion of this degree by a full-time student. New students are not admitted to the program; consult the department for more information.

**Doctor of Philosophy and Doctor of Science**

Aero-Astro offers doctoral degrees (PhD and ScD) that emphasize in-depth study, with a significant research project in a focused area. Admission to the doctoral program requires students to pass a graduate-level examination in a field of aerospace engineering as well as to demonstrate an ability to conduct field research. 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 entitled 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 Bioastronautics 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 also 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. For further descriptions of these programs, please see the listing for the Center for Biomedical Engineering in the section on Interdisciplinary Research and Study in Part 3. 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://web.mit.edu/cdo-program/index.html.

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, law, 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 Center for Transportation and Logistics. A special interdepartmental program may be established for the doctoral student, or participation in the Operations Research Center program may be considered—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 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 SM in management or an MBA, and an SM from a participating engineering department. The program is offered jointly through the MIT Sloan School of Management and the School of Engineering. For more information, see the program description under Engineering Systems Division or visit http://lgo.mit.edu/.

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://tppserver.mit.edu/.

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 academic, research, and interdisciplinary programs in the department, contact Marie Stuppard, mas@mit.edu. For information concerning admissions, financial aid and assistantships, contact Barbara Lechner, blechner@mit.edu, or Beth Marois, bethamar@mit.edu.

**Research Laboratories and Activities**

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.

**Aerospace Controls Laboratory**
The Aerospace Controls Laboratory (ACL) researches 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.

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**
Research at the Gas Turbine Laboratory is focused on advanced propulsion systems and turbomachinery with activities in computational, theoretical, and experimental study of: loss mechanisms and unsteady flows in turbomachines, compression system stability and active control, heat transfer in turbomachinery, gas turbine engine noise reduction and aeroacoustics, pollutant emissions and community noise, small-scale high-power-density engines, and analysis of advanced propulsion system and aircraft configurations. Past research projects include “micro engines” and millimeter-diameter gas turbine engines with blading fabricated using microfabrication techniques. Another project, the Silent Aircraft Initiative, was a collaboration with Cambridge University, Boeing, Rolls Royce, and other industrial partners to dramatically reduce aircraft noise. Current research includes work on instabilities in centrifugal compressors, aero-acoustics of counter-rotating propfan engines, design and assessment of hybrid-wing body aircraft configurations and embedded propulsion systems, acoustic propagation of fan noise in S-shaped inlet ducts, demonstration of small-scale turbomachinery for portable power, and novel aircraft configurations with reduced environmental impact.

**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, design of complex acquisition displays, human supervisory control of multiple heterogeneous unmanned vehicles; and developing and applying metrics for human supervisory systems.

**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 Engineering Systems Division, the Center for Transportation and Logistics, and the Operations Research Center.

**Lean Advancement Initiative**

The Lean Advancement Initiative (LAI) at MIT, together with its Educational Network, offers its 63 organizational members from industry, government, and academia the newest and best thinking, products, and tools related to lean enterprise transformation. A unique and powerful research consortium, LAI provides a neutral forum for sharing research findings, lessons learned, and best practices. LAI’s work is designed to enable enterprises to effectively, efficiently, and reliably create value in complex and rapidly changing environments. LAI enables the focused and accelerated transformation of complex enterprises through collaborative stakeholder engagement in developing and institutionalizing principles, processes, behaviors, and tools for enterprise excellence. 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.

**Partnership for Air Transportation Noise and Emissions Reduction**

The Partnership for Air Transportation Noise and Emissions Reduction is an Aero-Astro led FAA/NASA/Transport Canada-sponsored Center of Excellence. PARTNER 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, Aero-Astro is active in PARTNER research such as mitigating aviation environmental impacts via the use of alternative fuels for aircraft; studies of aircraft particulate matter microphysics and chemistry; and a study of reducing vertical separations required between commercial aircraft, which may enhance operating efficiency by making available more fuel/time efficient-flight levels, and enhancing air traffic control flexibility and airspace capacity.

Aero-Astro’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.

**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.

**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. A good part of the current focus of the laboratory reflects its broadening into other areas, including nano-engineered hybrid advanced composite design, fabrication, and testing; carbon-nanotube–based nanocomposite synthesis, characterization, and modeling; and design, fabrication, and testing of microelectromechanical systems together with their associated materials and processes. This broadening is manifested in TELAMS being the home of MIT’s Nano-Engineered Composite Aerospace Structures Consortium.

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 instruction 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.

FACULTY AND STAFF

Faculty and Teaching Staff
Ian Anton Waitz, PhD
Jerome C. Hunsaker Professor of Aeronautics and Astronautics
MacVicar Faculty Fellow
Department Head

David Louis Darmofal, PhD
Associate Professor Aeronautics and Astronautics
MacVicar Faculty Fellow
Associate Department Head

Professors
Edward Francis Crawley, ScD
Ford Professor of Aeronautics and Astronautics and Engineering Systems
Director, Bernard M. Gordon–MIT Engineering Leadership Program

Mark Drela, PhD
Professor of Aeronautics and Astronautics
Terry J. Kohler Professor of Fluid Dynamics

Steven Dubowsky, ScD
Professor of Mechanical Engineering and Aeronautics and Astronautics

Alan Harry Epstein, PhD
Richard Cockburn Maclaurin Professor of Aeronautics and Astronautics

Edward Marc Greitzer, PhD
H. N. Slater Professor of Aeronautics and Astronautics

Steven Ray Hall, ScD
Professor of Aeronautics and Astronautics
MacVicar Faculty Fellow

Robert John Hansman, Jr., PhD
T. Wilson Professor of Aeronautics and Astronautics and Engineering Systems

Wesley L. Harris, PhD
Charles Stark Draper Professor of Aeronautics and Astronautics

Associate Provost for Faculty Equity

Daniel Edgar Hastings, PhD
Professor of Aeronautics and Astronautics and Engineering Systems

Dean for Undergraduate Education

Jeffrey Alan Hoffman, PhD
Professor of the Practice of Aeronautics

Jonathan Patrick How, PhD
Professor of Aeronautics and Astronautics

Paul Alfred Lagacé, PhD
Professor of Aeronautics and Astronautics and Engineering Systems

Nancy Gail Leveson, PhD
Professor of Aeronautics and Astronautics and Engineering Systems

Robert Liebeck, PhD
Professor of the Practice of Aerospace Engineering

Manuel Martínez-Sánchez, PhD
Professor of Aeronautics and Astronautics

David W. Miller, ScD
Professor of Aeronautics and Astronautics

Dava Jean Newman, PhD
Professor of Aeronautics and Astronautics and Engineering Systems

MacVicar Faculty Fellow
Director, Technology and Policy Program

Deborah J. Nightingale, PhD
Professor of the Practice of Aeronautics and Astronautics and Engineering Systems

Amedeo Rodolfo Odoni, PhD
Professor of Aeronautics and Astronautics and Civil and Environmental Engineering

Jaume Peraire, PhD
Professor of Aeronautics and Astronautics

Sheila Evans Widnall, ScD
Professor of Aeronautics and Astronautics and Engineering Systems

Institute Professor

Brian Charles Williams, PhD
Professor of Aeronautics and Astronautics

Laurence Retman Young, ScD
Apollo Program Professor of Astronautics

Professor of Health Sciences and Technology

Associate Professors
M. L. Cummings, PhD
Associate Professor of Aeronautics and Astronautics and Engineering Systems

Olivier Ladjislas de Weck, PhD
Associate Professor of Aeronautics and Astronautics and Engineering Systems

Emilio Frazzoli, PhD
Associate Professor of Aeronautics and Astronautics

Eytan Modiano, PhD
Associate Professor of Aeronautics and Astronautics

Raúl Alberto Radovitzky, PhD
Associate Professor of Aeronautics and Astronautics

Nicholas Roy, PhD
Associate Professor of Aeronautics and Astronautics

Zoltan Sandor Spakovszky, PhD
Associate Professor of Aeronautics and Astronautics

Karen Elizabeth Willcox, PhD
Associate Professor of Aeronautics and Astronautics
Moe Win, PhD
Associate Professor of Aeronautics and Astronautics

Assistant Professors
Hamsa Balakrishnan, PhD
Assistant Professor of Aeronautics and Astronautics and Engineering Systems
Paul Cesar Lozano, PhD
Associate Professor of Aeronautics and Astronautics
Youssef Marzouk, PhD
Boeing Assistant Professor of Aeronautics and Astronautics
Annalisa Lynn Weigel, PhD
Assistant Professor of Aeronautics and Astronautics and Engineering Systems

Visiting Faculty
Nicholas Cumpsty, PhD
Vassilis Tsouassidis, PhD
David J. Willis, PhD

Visiting Scientists/Engineers
Tomoki Kawakubo, MEng
Boo Cheong Khoo, PhD
Ju-Whan Kim, BS

Senior Lecturers
Richard Horace Battin, PhD
Fredric Franklin Ehrich, ScD
John E. Keese, MS, Colonel USAF (Ret)
Rudrapatna V. Ramnath, PhD

Lecturers
Peter Paul Belobaba, PhD
Brian N. Nield, MS
John Tylko, BS
Erika Wagner, PhD

Academic Staff
Doris R. Brodeur, PhD
Diane Hauer Soderholm, PhD

Technical Instructors
Todd R. Billings
Richard Frank Perdichizzi
David Robertson

Research Staff

Senior Research Engineers
Charles McMaster Oman, PhD
Choon Sooi Tan, PhD

Principal Research Engineers
Robert Haines, MS
James Hileman, PhD

Principal Research Scientist
Peter Paul Belobaba, PhD

Research Engineers
Joseph A. Palladino, PhD
William Swelbar, MBA

Research Scientists
Woo Sik Kim, PhD
Andrew Liu, PhD
Alan Natapoff, PhD
Ngoc-Cuong Nguyen, PhD
Alvar Saenz-Otero, PhD

Research Specialists
Paul Henry Bauer, BS
John J. Kane, Jr., BS
James M. Letendre

Postdoctoral Fellows
Mehdi Ansari-Sadrabadi, PhD
Christoph Martin Wollersheim, PhD
Enrico Stoll, PhD

Postdoctoral Associates
Luca Bertuccelli, PhD
Philippe Bonnefoy, PhD
Gergana Bounova, PhD
Marcelo Buffoni, PhD
Birsen Donmez, PhD
Hai Duong, PhD
Michalis Frangos, PhD
Roberto Guzmán de Villoria, PhD
James M. A. Waldie, PhD

Professors Emeriti

Eugene Edzards Covert, ScD
Professor of Aeronautics and Astronautics, Emeritus

John Dugundji, ScD
Professor of Aeronautics and Astronautics, Emeritus

Shaoul Ezekiel, ScD
Professor of Aeronautics and Astronautics and Electrical Engineering, Emeritus

Robert Louis Halfman, SM
Professor of Aeronautics and Astronautics, Emeritus

Norman Douglas Ham, ScD
Professor of Aeronautics and Astronautics, Emeritus

Walter Mark Hollister, ScD
Professor of Aeronautics and Astronautics, Emeritus

Jack Leo Kerrebrock, PhD
Professor of Aeronautics and Astronautics, Emeritus

Yao Tzu Li, ScD
Professor of Aeronautics and Astronautics, Emeritus

James Wah Mar, ScD
Professor of Aeronautics and Astronautics, Emeritus

Winston Roscoe Markay, ScD
Professor of Aeronautics and Astronautics, Emeritus

Earl Morton Murman, PhD
Ford Professor of Engineering, Emeritus
Professor of Aeronautics and Astronautics and Engineering Systems, Emeritus

Theodore Hsueh-Huang Pian, ScD
Professor of Aeronautics and Astronautics, Emeritus

Thomas Brown Sheridan, ScD, D (hon)
Professor of Aeronautics and Astronautics and Engineering and Applied Psychology, Emeritus

Robert Warren Simpson, PhD
Professor of Aeronautics and Astronautics, Emeritus

Leon Trilling, PhD
Professor of Aeronautics and Astronautics, Emeritus
The mission of the Department of Biological Engineering (BE) is to educate leaders and generate and communicate new knowledge fusing engineering with modern molecular-to-genomic biology. Combining quantitative, physical, and integrative principles with advances in mechanistic molecular and cellular bioscience, biological engineering increases understanding of how biological systems function as both physical and chemical mechanisms, and of how they respond when perturbed by factors such as medical therapeutics, environmental agents, and genetic variation. Through this understanding, new technologies can be created to improve human health in a variety of medical and environmental applications, and biology-based paradigms can be generated to address many of the diverse challenges facing society.

The BE Department’s central aim is to establish a new, biology-based engineering discipline, alongside well-established disciplines such as chemical engineering, electrical engineering, and mechanical engineering. At the same time, the program endeavors to assist these engineering and science disciplines in addressing the impact of new processes and products relating to human health and the environment. To meet these objectives, BE comprises faculty with expertise in key areas of engineering, biology, biochemistry, biophysics, pharmacology, toxicology, and other relevant physical/chemical/computational sciences, and who share a goal of integrating central principles to pioneer innovative research and education direction at this nexus.

The department’s premise is that the science of biology is as important to the development of technology and society today as physics and chemistry were in the 20th century, and that the growing ability to monitor, assess, and control properties of living organisms at the molecular, cellular, tissue, organ, and systems 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 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 other devices, as well as for application 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.

Enrollment in the Biological Engineering SB program is limited at the present time, and students who wish to pursue this degree must complete the sophomore fall-term subject 20.110 Thermodynamics of Biomolecular Systems with a passing grade in order to apply for admission. This subject also fulfills an SB degree requirement in Biology. Students are also encouraged to take Organic Chemistry I and Differential Equations by the fall term of sophomore year in order to prepare for spring-term sophomore subjects. The sophomore spring-term curriculum includes an introductory biological engineering laboratory subject that provides context for the lecture subjects and a strong foundation for subsequent undergraduate research in biological engineering through Undergraduate Research Opportunity 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 four thematic areas: systems biology, 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.
Core Subjects
20.102 Macroepidemiology 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
1.725J Chemicals in the Environment: Fate and Transport
1.89 Environmental Microbiology
5.07 General Biochemistry
7.05 General Biology I
7.06 Cell Biology
7.28 Molecular Biology
5.23 Atmospheric Chemistry
17.32 Environmental Politics and Policy

Bachelor of Science in Biological Engineering/Course 20

General Institute Requirements (GIrs)

<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</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 Course 20 Program
Subject names below are followed by credit units, and by prerequisites if any (corequisites in italics).

<table>
<thead>
<tr>
<th>Subject Name</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.03 Differential Equations</td>
<td>12</td>
</tr>
<tr>
<td>20.310 Thermodynamics of Biomolecular Systems</td>
<td>12</td>
</tr>
<tr>
<td>20.104J Chemicals in the Environment: Fate and Transport</td>
<td>12</td>
</tr>
<tr>
<td>20.380 Senior Biological Engineering Design</td>
<td>12</td>
</tr>
<tr>
<td>20.309J Biological Engineering III Instrumentation and Measurement</td>
<td>12</td>
</tr>
<tr>
<td>20.310 Thermodynamic of Biomolecular Systems</td>
<td>12</td>
</tr>
<tr>
<td>20.109J Laboratory Fundamentals in Biological Engineering</td>
<td>12</td>
</tr>
<tr>
<td>5.12 Organic Chemistry</td>
<td>12</td>
</tr>
<tr>
<td>6.00 Introduction to Computer Science and Programming</td>
<td>12</td>
</tr>
<tr>
<td>5.07 General Biochemistry</td>
<td>12</td>
</tr>
<tr>
<td>7.05 General Biology I</td>
<td>12</td>
</tr>
<tr>
<td>7.02 Introduction to Experimental Biology and Communication</td>
<td>12</td>
</tr>
<tr>
<td>7.06 Cell Biology</td>
<td>12</td>
</tr>
<tr>
<td>7.28 Molecular Biology</td>
<td>12</td>
</tr>
<tr>
<td>5.310 Laboratory Chemistry</td>
<td>12</td>
</tr>
<tr>
<td>7.06 Environmental Microbiology</td>
<td>12</td>
</tr>
<tr>
<td>5.23 Atmospheric Chemistry</td>
<td>12</td>
</tr>
</tbody>
</table>

Total Units Beyond the GIrs Required for SB Degree
195–198

Restrictive Electives (Tracks TBD)
21–24

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, and the Whitehead Institute for Biomedical Research, 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.
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:

- 20.420 Biomedical Engineering Fundamentals
- 20.430 Biomedical Engineering Systems Dynamics
- 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/device systems 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 cell biology has not been taken previously, it must be taken as a remedial undergraduate subject before selecting the two graduate-level subjects. In addition, one undergraduate subject from Biological Engineering or one of the advanced engineering subjects is required, either before admission or during the second term.

The student selects a research advisor and begins research before the end of the first year. The oral part of the doctoral qualifying examinations, centered on the 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. Approximately five years of total residence are needed to complete the doctoral thesis and other degree requirements.

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:

- 20.420 Biomedical Engineering Fundamentals
- 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. The student will be expected to have biochemistry and cell biology as prerequisites and then select two graduate-level subjects in biological science. If cell biology has not been taken previously, it must be selected as one of these two graduate-level subjects. If biochemistry has not been taken previously, it must be taken as a remedial undergraduate subject before selecting the two graduate-level subjects. In addition, one graduate-level subject from Biological Engineering or one of the advanced engineering subjects is required as electives. The written part of the doctoral qualifying examinations, 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 applied biosciences track complements the bioengineering track (and the Computational and Systems Biology graduate program) 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, biochem-
istry, 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 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. Interdisciplinary in nature, the program and other programs and departments share an interest in human pathophysiology, molecular pharmacology, and environmental health.

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 (5.112); 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 Professor Jongyoon Han, jyhan@mit.edu; Professor Darrell Irvine, djivrine@mit.edu; or the BE Academic Office, Room 56-651, 617-253-1712.

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:
20.410J Molecular, Cellular, and Tissue Biomechanics
20.420J Biomolecular Kinetics and Cellular Dynamics
20.430J Fields, Forces, and Flows in Biological Systems

Biomedical Engineering Electives
24 units selected 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 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 SM in management or an MBA, and an SM from a participating engineering department. The program is offered jointly through the MIT Sloan School of Management and the School of Engineering. For more information, see the program description under Engineering Systems Division or visit http://lgo.mit.edu/.

Faculty and Staff

Faculty and Teaching Staff
Douglas A. Lauffenburger, PhD
Whitaker Professor of Biological Engineering, Biology, and Chemical Engineering
Associate Member, Broad Institute
Department Head

Professors
Angela M. Belcher, PhD
Germeshausen Professor of Materials Science and Biological Engineering
Arup Chakraborty, PhD
Haslam Professor of Chemical Engineering, Chemistry, and Biological Engineering
Peter C. Dedon, PhD, MD
Underwood-Prescott Professor of Toxicology and Biological Engineering
Edward F. DeLong, PhD
Professor of Environmental and Biological Engineering
Associate Member, Broad Institute

C. Forbes Dewey, Jr., PhD
Professor of Mechanical Engineering and Bioengineering

John Martin Essigmann, PhD
Professor of Chemistry, Toxicology, and Biological Engineering

James G. Fox, DVM
Professor of Toxicology
Director, Division of Comparative Medicine

Linda Griffith, PhD
S.E.T.I. Professor of Biological and Mechanical Engineering
Director, Biotechnology Process Engineering Center

Alan J. Grodzinsky, PhD
Professor of Electrical, Mechanical, and Biological Engineering
Director, Center for Biomedical Engineering

Robert D. Kamm, PhD
Germeshausen Professor of Biological and Mechanical Engineering

Alexander M. Klibanov, PhD
Novartis Professor of Chemistry and Biological Engineering

Robert S. Langer, ScD
Professor of Chemical and Biomedical Engineering
Institute Professor

Harvey F. Lodish, PhD
Professor of Biology and Biological Engineering
Associate Member, Broad Institute
Member, Whitehead Institute for Biomedical Research

Leona D. Samson, PhD
American Cancer Society Professor
Professor of Toxicology and Biological Engineering
Associate Member, Broad Institute
Director, Center for Environmental Health Sciences

Ram Sasisekharan, PhD
Taplin Professor of Biological Engineering and Health Sciences and Technology

Peter T. So, PhD
Professor of Mechanical and Biological Engineering

Steven R. Tannenbaum, PhD
Underwood-Prescott Professor of Toxicology and Chemistry

William G. Thilly, ScD
Professor of Toxicology

Bruce Tidor, PhD
Professor of Biological Engineering and Computer Science

K. Dane Wittrup, PhD
Mares Professor of Chemical Engineering and Biological Engineering

Michael B. Yaffe, PhD
Professor of Biology and Biological Engineering

Jacquelyn C. Yanch, PhD
Professor of Nuclear Science and Engineering and Biological Engineering

Ioannis V. Yannis, PhD
Professor of Polymer Science and Bioengineering

Edward F. DeLong, PhD
Professor of Environmental and Biological Engineering
Associate Member, Broad Institute

C. Forbes Dewey, Jr., PhD
Professor of Mechanical Engineering and Bioengineering

John Martin Essigmann, PhD
Professor of Chemistry, Toxicology, and Biological Engineering

James G. Fox, DVM
Professor of Toxicology
Director, Division of Comparative Medicine

Linda Griffith, PhD
S.E.T.I. Professor of Biological and Mechanical Engineering
Director, Biotechnology Process Engineering Center

Alan J. Grodzinsky, PhD
Professor of Electrical, Mechanical, and Biological Engineering
Director, Center for Biomedical Engineering

Robert D. Kamm, PhD
Germeshausen Professor of Biological and Mechanical Engineering

Alexander M. Klibanov, PhD
Novartis Professor of Chemistry and Biological Engineering

Robert S. Langer, ScD
Professor of Chemical and Biomedical Engineering
Institute Professor

Harvey F. Lodish, PhD
Professor of Biology and Biological Engineering
Associate Member, Broad Institute
Member, Whitehead Institute for Biomedical Research

Leona D. Samson, PhD
American Cancer Society Professor
Professor of Toxicology and Biological Engineering
Associate Member, Broad Institute
Director, Center for Environmental Health Sciences

Ram Sasisekharan, PhD
Taplin Professor of Biological Engineering and Health Sciences and Technology

Peter T. So, PhD
Professor of Mechanical and Biological Engineering

Steven R. Tannenbaum, PhD
Underwood-Prescott Professor of Toxicology and Chemistry

William G. Thilly, ScD
Professor of Toxicology

Bruce Tidor, PhD
Professor of Biological Engineering and Computer Science

K. Dane Wittrup, PhD
Mares Professor of Chemical Engineering and Biological Engineering

Michael B. Yaffe, PhD
Professor of Biology and Biological Engineering

Jacquelyn C. Yanch, PhD
Professor of Nuclear Science and Engineering and Biological Engineering

Ioannis V. Yannis, PhD
Professor of Polymer Science and Bioengineering

Edward F. DeLong, PhD
Professor of Environmental and Biological Engineering
Associate Member, Broad Institute

C. Forbes Dewey, Jr., PhD
Professor of Mechanical Engineering and Bioengineering

John Martin Essigmann, PhD
Professor of Chemistry, Toxicology, and Biological Engineering

James G. Fox, DVM
Professor of Toxicology
Director, Division of Comparative Medicine

Linda Griffith, PhD
S.E.T.I. Professor of Biological and Mechanical Engineering
Director, Biotechnology Process Engineering Center

Alan J. Grodzinsky, PhD
Professor of Electrical, Mechanical, and Biological Engineering
Director, Center for Biomedical Engineering

Robert D. Kamm, PhD
Germeshausen Professor of Biological and Mechanical Engineering

Alexander M. Klibanov, PhD
Novartis Professor of Chemistry and Biological Engineering

Robert S. Langer, ScD
Professor of Chemical and Biomedical Engineering
Institute Professor

Harvey F. Lodish, PhD
Professor of Biology and Biological Engineering
Associate Member, Broad Institute
Member, Whitehead Institute for Biomedical Research

Leona D. Samson, PhD
American Cancer Society Professor
Professor of Toxicology and Biological Engineering
Associate Member, Broad Institute
Director, Center for Environmental Health Sciences

Ram Sasisekharan, PhD
Taplin Professor of Biological Engineering and Health Sciences and Technology

Peter T. So, PhD
Professor of Mechanical and Biological Engineering

Steven R. Tannenbaum, PhD
Underwood-Prescott Professor of Toxicology and Chemistry

William G. Thilly, ScD
Professor of Toxicology

Bruce Tidor, PhD
Professor of Biological Engineering and Computer Science

K. Dane Wittrup, PhD
Mares Professor of Chemical Engineering and Biological Engineering

Michael B. Yaffe, PhD
Professor of Biology and Biological Engineering

Jacquelyn C. Yanch, PhD
Professor of Nuclear Science and Engineering and Biological Engineering

Ioannis V. Yannis, PhD
Professor of Polymer Science and Bioengineering

Edward F. DeLong, PhD
Professor of Environmental and Biological Engineering
Associate Member, Broad Institute

C. Forbes Dewey, Jr., PhD
Professor of Mechanical Engineering and Bioengineering

John Martin Essigmann, PhD
Professor of Chemistry, Toxicology, and Biological Engineering

James G. Fox, DVM
Professor of Toxicology
Director, Division of Comparative Medicine

Linda Griffith, PhD
S.E.T.I. Professor of Biological and Mechanical Engineering
Director, Biotechnology Process Engineering Center

Alan J. Grodzinsky, PhD
Professor of Electrical, Mechanical, and Biological Engineering
Director, Center for Biomedical Engineering

Robert D. Kamm, PhD
Germeshausen Professor of Biological and Mechanical Engineering

Alexander M. Klibanov, PhD
Novartis Professor of Chemistry and Biological Engineering

Robert S. Langer, ScD
Professor of Chemical and Biomedical Engineering
Institute Professor

Harvey F. Lodish, PhD
Professor of Biology and Biological Engineering
Associate Member, Broad Institute
Member, Whitehead Institute for Biomedical Research

Leona D. Samson, PhD
American Cancer Society Professor
Professor of Toxicology and Biological Engineering
Associate Member, Broad Institute
Director, Center for Environmental Health Sciences

Ram Sasisekharan, PhD
Taplin Professor of Biological Engineering and Health Sciences and Technology

Peter T. So, PhD
Professor of Mechanical and Biological Engineering

Steven R. Tannenbaum, PhD
Underwood-Prescott Professor of Toxicology and Chemistry

William G. Thilly, ScD
Professor of Toxicology

Bruce Tidor, PhD
Professor of Biological Engineering and Computer Science

K. Dane Wittrup, PhD
Mares Professor of Chemical Engineering and Biological Engineering

Michael B. Yaffe, PhD
Professor of Biology and Biological Engineering

Jacquelyn C. Yanch, PhD
Professor of Nuclear Science and Engineering and Biological Engineering

Ioannis V. Yannis, PhD
Professor of Polymer Science and Bioengineering

Associate Professors

Christopher B. Burge, PhD
Whitehead Associate Professor of Biology and Biological Engineering
Associate Member, Broad Institute

Bevin P. Engelward, DSc
Associate Professor of Biological Engineering

Jongyoon Han, PhD
van Tassel Associate Professor of Electrical and Biological Engineering

Darrell J. Irvine, PhD
Associate Professor of Biological Engineering and Materials Science
Howard Hughes Medical Institute Investigator

Alan P. Jasanoff, PhD
Pfizer-Laubach Assistant Professor of Biological Engineering

Katharina Ribbeck, PhD
Assistant Professor of Biological Engineering

Visiting Professor

Peter K. Sorger, PhD
Visiting Professor of Biological Engineering

Lecturers and Instructors

Noubar Afeyan, PhD
Laura C. Green, PhD
Sean Harriman, PhD
Natalie Kuldey, PhD
Agi Stachowiak, PhD
Nathan Tedford, PhD
Steve Wasserman, SM
Research Staff

*Senior Research Scientist*
John S. Wishnok, PhD

*Principal Research Scientist*
Paul L. Skipper, PhD

*Principal Research Engineer*
Randall Rettberg, MS

*Research Scientists*
Robert G. Croy, PhD
Michael DeMott, PhD
Karel Domansky, PhD
Elena Gostjjeva, PhD
Ramesh Indrakanti, PhD
Vera Koledova, PhD
Rosa Liberman, PhD
Robert McCunney, PhD
Rahul Raman, PhD

*Deyu Li, PhD
Kok Seong Lim, PhD
Pallavi Lonkar, PhD
Megan McBee, PhD
Geeta Mehta, PhD
Shmuel Motola, PhD
Jason Neil, PhD
Dawn Nida, PhD
Gerard Ostheimer, PhD
Ho Seok Park, PhD
Yang Shen, PhD
Peter Slade, PhD
Hsiao-Lan Sun, PhD
Kirill Titeievsky, PhD
Lianrong Wang, PhD
Yu Wang, PhD
Courtney Williams, PhD
Wenjie Ye, PhD
Yu Zeng, PhD

*Research Associate*
Min Young Kim, PhD

*Postdoctoral Associates*
Shannon Alford, PhD
Neda Bagheri, PhD
Viral Brahmbhatt, PhD
Wan Chan, PhD
Nisanart Charoenlap, PhD
David Clarke
Liang Cui, PhD
Ajit Dash, PhD
Amanda Del Rosario, PhD
Jeannette Fiala, PhD
Alfio Fichera, PhD
Mark Fleury, PhD
Kevin Ford, PhD
Luiz Godoy, PhD
William Grover, PhD
Arthur Goldsipe, PhD
Toomas Haller, PhD
Peyman Honarmandi, PhD
Hannah Johnson, PhD
Pilsoo Kang, PhD
Hyung-Do Kim, PhD
Orsolya Kiraly, PhD
Scott Knudsen, PhD
Charles Knutson, PhD
Jungchul Lee, PhD
Taekwan Lee, 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, advancement of life sciences, production of new materials, chemical engineers make their products and processes a reality.

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 without creditation for this degree is anticipated. Course 10-C 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. ABET accreditation for this degree is anticipated. 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.

### Bachelor of Science in Chemical Engineering/Course 10

#### General Institute Requirements (GIRs)

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Science Requirement</strong></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; 5.07 or 7.05; 5.60; 10.301; and 18.03 or 18.034 in the Departmental Program]</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement [can be satisfied by 5.310]</td>
<td>1</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>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Required Subjects</strong></td>
<td>162</td>
</tr>
<tr>
<td>5.12 Organic Chemistry I, 12, REST; Chemistry (GIR)</td>
<td>5.07 Biological Chemistry I, 12, REST; 5.12 or 7.05 General Biochemistry, 12, REST; 5.12, Biology (GIR); or permission of instructor</td>
</tr>
<tr>
<td><strong>One of the following three subjects:</strong></td>
<td>6</td>
</tr>
<tr>
<td>10.26 Chemical Engineering Projects Laboratory, 15, CI-M; 5.310, 7.02, or 10.702; 10.302</td>
<td>10.28 Chemical-Biological Engineering Lab, 15, CI-M; 5.310, 7.02, or 10.702; 7.05 or 5.07; or permission of instructor</td>
</tr>
<tr>
<td><strong>plus</strong></td>
<td>10.301 Fluid Mechanics, 12, REST; 18.03, 10.10</td>
</tr>
<tr>
<td>10.491 Integrated Chemical Engineering II, 10.490*</td>
<td>One of the following three subjects:</td>
</tr>
<tr>
<td>10.03 Differential Equations, 12, REST; Calculus II (GIR)</td>
<td>or</td>
</tr>
<tr>
<td><strong>Restricted Electives</strong></td>
<td>24</td>
</tr>
<tr>
<td>One subject in Chemical Engineering, except 10.UR, 10.URG, 10.THUR, 10.04, 10.792L, 10.801-10.816, 10.90-10.999</td>
<td>plus one laboratory subject from the following list:</td>
</tr>
<tr>
<td>5.36 Biochemistry and Organic Laboratory, 12, CI-M</td>
<td>—Module 4 Expression and Purification of Enzyme Mutants, 4; 5.07 or 7.05; Module 2 or 5.310, Module 5</td>
</tr>
<tr>
<td>7.02 Introduction to Experimental Biology and Communication, 18, CI-M, LAB; Biology (GIR)</td>
<td>10.492 Polymer Science Laboratory, 15, CI-M; 5.12, 5.310</td>
</tr>
<tr>
<td>10.29 Biological Engineering Projects Laboratory, 15, CI-M; 5.310, 7.02 or 10.702; 10.302</td>
<td>10.702 Introductory Experimental Biology and Communication, 18, CI-M, LAB; Biology (GIR)</td>
</tr>
</tbody>
</table>
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 course 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 5.11/5.111/5.112 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.

Additional information is available on the Chemical Engineering Department website at [http://web.mit.edu/cheme/](http://web.mit.edu/cheme/). Undergraduates are encouraged to partake in the research activities of the department through the Undergraduate Research Opportunities Program (UROP).

**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, 3.155/6.152J, 5.36, 7.02I/10.702J, 10.26, 10.28 or 10.28L, 10.29 or 10.467;

and

an additional subject from the above list or the following:

1.018, 6.021J, 6.033, 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.

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.

---

**Bachelor of Science in Chemical-Biological Engineering/Course 10-B**

**General Institute Requirements (GIRs)**

<table>
<thead>
<tr>
<th>Subject names below are followed by credit units, and by prerequisites if any (corequisites in italics)</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Required Subjects</strong></td>
<td>186</td>
</tr>
<tr>
<td>5.12 Organic Chemistry I, 12; REST; Chemistry (GIR)</td>
<td>6</td>
</tr>
<tr>
<td>5.50 Thermodynamics and Kinetics, 12; REST; Calculus II (GIR), Chemistry (GIR)</td>
<td>8</td>
</tr>
<tr>
<td>7.02 Introduction to Experimental Biology and Communication, 18, CI-M, LAB; Biology (GIR) or 10.702 Introduction to Experimental Biology and Communication, 18, CI-M, LAB; Biology (GIR)</td>
<td>2</td>
</tr>
<tr>
<td>7.03 Genetics, 12, REST; Biology (GIR)</td>
<td>1</td>
</tr>
<tr>
<td>7.05 General Biochemistry, 12, REST; 5.12, Biology (GIR); or permission of instructor or 5.07 Biological Chemistry I, 12, REST; 5.12</td>
<td>17</td>
</tr>
<tr>
<td>7.06 Cell Biology, 12; 7.03, 7.05*</td>
<td>17</td>
</tr>
<tr>
<td>10.10 Introduction to Chemical Engineering, 12; Physics I (GIR), Calculus I (GIR), Chemistry (GIR)</td>
<td>2</td>
</tr>
<tr>
<td>10.213 Chemical and Biological Engineering Thermodynamics, 12; 5.60, 10.10</td>
<td>1</td>
</tr>
<tr>
<td>10.28 Chemical-Biological Engineering Laboratory, 15, CI-M; 5.310, 7.02, or 10.702; 7.05 or 5.07; or permission of instructor or 10.29 Biological Engineering Projects Laboratory, 15, CI-M; 5.310, 7.02, or 10.702; 10.302</td>
<td>48</td>
</tr>
<tr>
<td>10.301 Fluid Mechanics, 12, REST; 18.03, 10.10</td>
<td>8</td>
</tr>
<tr>
<td>10.302 Transport Processes, 12; 10.301*</td>
<td>48</td>
</tr>
</tbody>
</table>

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:
18.03 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**

**Unrestricted Electives**

(36)

**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. 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](http://student.mit.edu/catalog/index.cgi).
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. The extension of classical thermodynamics to molecular scales by use of statistical mechanics has made molecular simulation an increasingly valuable tool for the chemical engineer. Prediction of macroscopic behavior from molecular computations is becoming ever more feasible. This venerable field continues to yield fruitful areas of inquiry.

Opportunities in the department for graduate study in this field include predicting properties of materials and polymers from molecular structure, applying quantum mechanics to catalyst design, supercritical fluid processing, the behavior of complex fluids with environmental and biomedical applications, phase equilibrium with simple and complex molecular species, immunology, protein stabilization, nucleation and crystallization of polymer and pharmaceuticals, and many other areas of classical and statistical thermodynamics.

Transport Processes. A fluid deforming and flowing as forces are imposed on it, its temperature varying as heat is transferred through it, the interdiffusion of its distinct molecular species—these are examples of the processes of transport. These transport processes govern the rates at which velocity, temperature, and composition vary in a fluid; chemical engineers study transport to be able to describe, predict, and manage these changes. Research includes experimental testing and analytical and computational modeling; its applications range among an enormous variety of mechanical, chemical, and biological processes.

Current work includes the study of polymer molecular theory and polymer processing, transport and separations in magnetorheological fluids, membrane separations, diffusion in complex fluids, defect formation and evolution in near-crystalline materials, microfluidics, fluid instability, transport in living tissue, numerical solution of field equations, and many other areas of transport phenomena.

Catalysis and Chemical Reaction Engineering. A simple chemical reaction—the rearrangement of electrons and bonding partners—occurs between two small molecules. From understanding the kinetics of the reaction, and the equilibrium extent to which it can proceed, come applications: the network of reactions during combustion, the chain reactions that form polymers, the multiple steps in the synthesis of 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 nanofibers, 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 bio-production 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.

**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. Meth-
Chemical Engineering

Mathematics.

Design, systems engineering, and applied one graduate subject, in each of the following required to demonstrate proficiency, or take 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 Practice

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 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://tppserver.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 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 SM in management or an MBA, and an SM from a participating engineering department. The program is offered jointly through the MIT Sloan School of Management and the School of Engineering. For more information, see the program description under Engineering Systems Division or visit http://lgo.mit.edu/.

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 Flemming Jensen, PhD
Warren K. Lewis Professor of Chemical Engineering
Department Head
Paula Therese Hammond, PhD
Bayer Professor of Chemical Engineering
Executive Officer

Professors

Robert C. Armstrong, PhD
Chevron Professor of Chemical Engineering
Professor of Chemical Engineering
Associate Director, MIT Energy Initiative
Paul I. Barton, PhD
Lammot du Pont Professor of Chemical Engineering
Daniel Blankschtein, PhD
Professor of Chemical Engineering
Arup K. Chakraborty, PhD
Robert T. Haslam Professor of Chemical Engineering
Professor of Chemistry and Biological Engineering
Graduate Admissions Officer
Robert E. Cohen, PhD
Raymond A. and Helen E. St. Laurent Professor of Chemical Engineering
Clark K. Colton, PhD
Professor of Chemical Engineering
Charles L. Cooney, PhD
Robert T. Haslam Professor of Chemical and Biochemical Engineering
Faculty Director, Deshpande Center for Technological Innovation
Codirector, Program on the Pharmaceutical Industry
William M. Deen, PhD
Carbon P. Dubbs Professor of Chemical Engineering
Graduate Officer
Karen K. Gleason, PhD
Alexander and I. Michael Kasser Professor of Chemical Engineering
Associate Dean for Research, School of Engineering
William H. Green, PhD
Professor of Chemical Engineering
T. Alan Hatton, PhD
Ralph Landau Professor of Chemical Engineering Practice
Director, David H. Koch School of Chemical Engineering Practice
Robert Samuel Langer, ScD
Institute Professor
Douglas A. Lauffenburger, PhD
Whitaker Professor of Biological Engineering, Chemical Engineering, and Biology
Associate Member, Broad Institute
Head, Biological Engineering Department
Gregory J. McRae, PhD
Hoyt C. Hotell Professor of Chemical Engineering
Gregory C. Rutledge, PhD
Lammot du Pont Professor of Chemical Engineering
Kenneth A. Smith, ScD
Edwin R. Gilliland Professor of Chemical Engineering
George Stephanopoulos, PhD
Arthur Dehon Little Professor of Chemical Engineering
Gregory Stephanopoulos, PhD
Herbert H. Dow Professor of Chemical Engineering
Jefferson W. Tester, PhD
Herman P. Meissner 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
Daniel I. C. Wang, PhD
Professor of Chemical Engineering
Institute Professor

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.
Karl D. Wittrup, PhD
Carbon T. Dubbs Professor of Chemical Engineering and Biological Engineering

**Associate Professors**

Martin Z. Bazant, PhD
Associate Professor of Chemical Engineering and Mathematics

Patrick S. Doyle, PhD
Associate Professor of Chemical Engineering

Michael S. Strano, PhD
Charles and Hilda Roddey Associate Professor of Chemical Engineering

Preetinder S. Virk, ScD
Associate Professor of Chemical Engineering

**Assistant Professors**

Jesse H. Kroll, PhD
Assistant Professor of Civil and Environmental Engineering and Chemical Engineering

J. Chris Love, PhD
Texaco-Mangelsdorf Assistant Professor of Chemical Engineering and Associate Member, Broad Institute

Narendra Maheshri, PhD
Raymond A. and Helen St. Laurent Assistant Professor of Chemical Engineering

Bradley D. Olsen, PhD
Assistant Professor of Chemical Engineering

Kristala J. Prather, PhD
Assistant Professor of Chemical Engineering

Hadley D. Sikes, PhD
Joseph R. Mares Assistant Professor of Chemical Engineering

**Adjunct Professor**

Jackie Y. R. Ying, PhD
Adjunct Professor of Chemical Engineering

**Senior Lecturers**

Robert Fisher, PhD

Barry S. Johnston, PhD

Industrial Development Officer

Undergraduate Officer

Claude Lupis, PhD

**Lecturers**

Bonnie D. Burrell, BA

William H. Dalzell, PhD

**Research Staff**

**Research Engineers**

Jean-François P. Hamel

Peter Kracke

**Research Scientists**

Luis Perez-Breva

Lev E. Bromberg

Joanne K. Kelleher

**Technical Assistants**

Adrian A. Fay

Itay Sagie

**Postdoctoral Associates**

Steven M. Abel

Syed Hussain Imam Abidi

Andrea Adamo

Thomas Adams

Miguel A. Amat

David Appleyard

Avni A. Argun

Ayse Asatekin Alexiou

Paul Barone

Soubir Basak

Georgios Bollas

Andrea Centrone

Keith Chadwick

Shujun Chen

Hao Cheng

Beata Chertok

Christina Cortez

Ujjal Das

Haim David Dressler

Yi Du

Dimitrios Gerogiorgis

Moon-Ho Ham

Jae-Hee Han

Ryan L. Hartman

Sung Gap Im

Godze Ince

Abhishek K. Jha

Sandeep S. Karajanagi

Veysel Kayser

Jong Ho Kim

Felix H. Lam

Sanghun Lee

Effendi Leonard

Kerry R. Love

Salvatore Mascia

Ying Mei

Christian Metallo

Rebekah A. Miller

Boaz Mizrahi

David R. Nielsen

Ajikumar Parayil Kumaran

Christie Ann Marie Peebles

Ketan P. Pimparkar

Rohit Ramachandran

Renu Ravindranath

Elizabeth Louise Read

Erik E. Santiso

Seyed-Abdolreza Seyed-Reihani

Fritz Simeon

Changsik Song

Qing Song

Ramaseswamy Sreenivasan

Sreream Vaddiranju

Nain Varadarajan

Vladimir Hristov Voinov

Jian Wen

Richard H. West

Qiaobing Xu

Ying Yang

Janeta Zoldan

**Postdoctoral Fellows**

Joon Hyun Baik

Seung Woo Cho

Ana Jaklenec

Jong Ho Kim

Woo-Jae Kim

Fan Yang

**Research Affiliates**

Steven A. Africk

Efstathios Avgoustiniatos

Anuj Bellare

Itzhak Isaac Berzin

Dhananjay Dendukuri

Yuliya Domnina

Sergey Fridrikh

Steven W. Griffiths

Jeffrey S. Hrkach

Orhan I. Karsiligil

Arthur L. Lafleur

Michael Modell

Eric M. Morrel
Orhun K. Muratoglu
Samuel Ngai
James J. Noble
Mahnaz Nouri
Victor A. Ovchinnikov
Klearchos K. Papas
Hyoungshin Park
Blaine A. Pfeifer
Jason M. Ploeger
Henning Richter
Maria Ann Rupnick
Sumil K. Sharma
Norman F. Sheppard, Jr.
Barry A. Solomon
Brian Curtis Stephenson
Brian R. Stoll
Mallikarjun Sundaram
Kathleen C. Swallow
Henri C. Tannas
Charles Alfred Vacanti
Joseph P. Vacanti

Adel F. Sarofim, ScD
Professor of Chemical Engineering, Emeritus

Charles N. Satterfield, PhD
Professor of Chemical Engineering, Emeritus

Herbert H. Sawin, PhD
Professor of Chemical and Electrical Engineering, Emeritus

James Wei, ScD
Professor of Chemical Engineering, Emeritus


Visiting Scientists

Takuya Harada
Shaoyi Jiang
Yong Hoon Kim
Joseph Kost
Akihiko Kusanagi
Russell P. Lachance
Kenji Takahashi

Professors Emeriti

Raymond F. Baddour, ScD
Professor of Chemical Engineering, Emeritus

János M. Beér, ScD
Professor of Chemical and Fuel Engineering, Emeritus

Howard Brenner, EngScD
Willard Henry Dow Professor of Chemical Engineering, Emeritus

Robert A. Brown, PhD
Warren K. Lewis Professor of Chemical Engineering, Emeritus

Marcus Karel, PhD
Professor of Chemical and Food Engineering, Emeritus

Edward W. Merrill, 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. 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 hydroclimatology), 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 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. These are complemented by design subjects that teach students to handle open-ended problems through involvement in increasingly complex team-oriented projects. Unrestricted electives and advanced restricted electives are typically used to build depth in particular areas.

The 1-C program provides the education necessary for professional practice in civil engineering as well as a number of 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 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 the natural environment and its interactions with human activities. Subjects in environmental transport and hydrology share a laboratory that emphasizes both hands-on skills and the use of measurements to test hypotheses. The environmental chemistry and biology subject is also accompanied by a laboratory. Concepts learned in these subjects are applied to questions of human health in an advanced upper-class subject. Unrestricted electives and advanced restricted electives are typically used to build depth in particular areas.

The 1-E program provides the education necessary for careers in environmental engineering and science, as well as in many other fields. It also gives a solid foundation for graduate study and research in both basic and applied environmental disciplines. The 1-E program is ABET accredited and is sufficiently flexible to prepare students for careers in medicine or environmental law.

Bachelor of Science in Civil Engineering/Course 1-C

General Institute Requirements (GIRs)  
Subjects Units
Science Requirement 6
Humanities, Arts, and Social Sciences Requirement 8
Restricted Electives in Science and Technology (REST) Requirement [can be satisfied by 1.00 or 1.018] 2
Laboratory Requirement [can be satisfied by 1.101 and 1.102 in the Departmental Program] 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 159
Core
1.018J Ecology I: The Earth System, 12, REST, CI-M
1.020 Ecology II: Engineering for Sustainability, 12; Physics I (GIR), 18.03*
1.050 Engineering Mechanics I, 12; Physics I (GIR), Calculus II (GIR)
1.060 Engineering Mechanics II, 12; permission of instructor*
18.03 Differential Equations, 12, REST; Calculus II (GIR)
1.101 Senior Civil and Environmental Engineering Design, 12, CI-M; permission of instructor
1.00 Introduction to Computers and Engineering Problem Solving, 12, REST; Calculus I (GIR)
1.010 Uncertainty in Engineering, 12; Calculus II (GIR)

Civil Engineering
1.011 Project Evaluation, 9
1.035 Mechanics of Structures and Soils, 18; 1.050, 18.03
1.036 Structural and Geotechnical Engineering Design, 12; 1.035
1.041J Engineering Systems Design, 12; 1.011*

Laboratory
1.101 Introduction to Civil & Environmental Engineering Design I, 6, 1/2 LAB; 1.018, 1.050
1.102 Introduction to Civil & Environmental Engineering Design II, 6, 1/2 LAB; 1.060, permission of instructor

Restricted Electives 12
One advanced subject from the following list:
1.015J Design of Electromechanical Robotic Systems, 12, 1/2 LAB; 2.003; 2.671, 2.005*
1.032 Geomatrics and Geomechanics, 12; 1.010, 1.011, 1.035, 1.036
1.052J Mechanics of Structures, 12; 1.050*
1.054 Mechanics and Design of Concrete Structures, 12; 1.035
1.202J Foundations of Software and Computation for Simulation, 12; 1.00*
1.200J Transportation Systems Analysis: Performance and Optimization, 12; 1.010, permission of instructor
1.201J Transportation Systems Analysis: Demand and Economics, 12; permission of instructor
1.242J Urban Transportation Planning, 12; permission of instructor
1.260J Logistics Systems, 12; permission of instructor
1.073J Structural Mechanics, 12; 2.002*

Departmental Program Units That Also Satisfy the GIRs 96
Unrestricted Electives 48

Total Units Beyond the GIRs Required for SB Degree 183
No subject can be counted both 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.
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 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 environmental biology, chemistry, or oceanography 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 1.018J) 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.

Bachelor of Science in Environmental Engineering Science/Course 1-E

<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 [one subject can be satisfied by 1.801J, 11.002, 11.102, or 14.01 in the Departmental Program]</td>
<td>8</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement [can be satisfied by 1.018J and 18.03 in the Departmental Program]</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement [can be satisfied by 1.101 and 1.102 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>
<th>Subjects</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>
<td>17</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PLUS Departmental Program</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject names below are followed by credit units, and by prerequisites if any (corequisites in italics).</td>
<td>168</td>
</tr>
<tr>
<td>Required Subjects</td>
<td>168</td>
</tr>
<tr>
<td>Core</td>
<td>1.018J Ecology I: The Earth System, 12, REST, CI-M</td>
</tr>
<tr>
<td>1.020 Ecology II: Engineering for Sustainability, 12; Physics I (GIR), 28.03*</td>
<td>8</td>
</tr>
<tr>
<td>1.050 Engineering Mechanics I, 12; Physics I (GIR), Calculus II (GIR)</td>
<td>2</td>
</tr>
<tr>
<td>1.060 Engineering Mechanics II, 12; permission of instructor*</td>
<td>1</td>
</tr>
<tr>
<td>18.03 Differential Equations, 12, REST; Calculus II (GIR)</td>
<td>1</td>
</tr>
<tr>
<td>1.013 Senior Civil and Environmental Engineering Design, 12, CI-M; permission of instructor</td>
<td>1</td>
</tr>
<tr>
<td>One of the following two subjects:</td>
<td>1</td>
</tr>
<tr>
<td>1.00 Introduction to Computers and Engineering Problem Solving, 12, REST; Calculus I (GIR)</td>
<td>2</td>
</tr>
<tr>
<td>1.010 Uncertainty in Engineering, 12; Calculus II (GIR)</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental Engineering Science</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.061 Transport Processes in the Environment, 12; 1.060</td>
<td>8</td>
</tr>
<tr>
<td>1.070J Introduction to Hydrology, 12; 1.060, 1.106</td>
<td>12</td>
</tr>
<tr>
<td>1.080 Environmental Chemistry and Biology, 12; Chemistry (GIR), Biology (GIR)</td>
<td>16</td>
</tr>
<tr>
<td>1.083 Environmental Health Engineering, 12; 1.106*</td>
<td>12</td>
</tr>
<tr>
<td>1.106 Environmental Fluid Transport Processes and Hydrology Laboratory, 6, 1/2 LAB; 1.061, 1.070J</td>
<td>8</td>
</tr>
<tr>
<td>1.107 Environmental Chemistry and Biology Laboratory, 6, 1/2 LAB; 1.080</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Economics and Public Policy</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>One of the following four subjects:</td>
<td>16</td>
</tr>
<tr>
<td>1.801J Environmental Law, Policy, and Economics: Pollution Prevention &amp; Control, 12; HASS</td>
<td>8</td>
</tr>
<tr>
<td>11.002J Making Public Policy, 12; HASS-D, CI-H</td>
<td>8</td>
</tr>
<tr>
<td>11.122 Society and Environment, 12; HASS</td>
<td>8</td>
</tr>
<tr>
<td>14.01 Principles of Microeconomics, 12; HASS</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Subjects</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>12</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>12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Restricted Elective</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>One advanced subject from the following list:</td>
<td>12</td>
</tr>
<tr>
<td>1.071J Global Change Science, 12; 18.03, 5.60</td>
<td>12</td>
</tr>
<tr>
<td>1.64 Physical Limnology, 12; 1.060, 1.061</td>
<td>12</td>
</tr>
<tr>
<td>1.69 Introduction to Coastal Engineering, 12; 1.061</td>
<td>12</td>
</tr>
<tr>
<td>1.72 Groundwater Hydrology, 12; 1.061</td>
<td>12</td>
</tr>
<tr>
<td>1.73 Water Resource Systems, 12; 1.070*</td>
<td>12</td>
</tr>
<tr>
<td>1.77 Water Quality Control, 12; 1.060</td>
<td>12</td>
</tr>
<tr>
<td>1.83 Environmental Organic Chemistry, 12; 5.60, 18.03</td>
<td>12</td>
</tr>
<tr>
<td>1.89 Environmental Microbiology, 12; 7.014</td>
<td>12</td>
</tr>
</tbody>
</table>
### 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 in civil and environmental engineering. The department works with many companies and agencies to ensure that attractive internship opportunities are available for qualified students. For more information and a partial listing of companies, see the Summer Internship Program description on the departmental website at [http://cee.mit.edu/](http://cee.mit.edu/).

### Undergraduate Practice Opportunities Program
The Undergraduate Practice Opportunities Program (UPOP) is sponsored by the School of Engineering and administered through the Office of the Dean of Engineering. UPOP is the sophomore component of the Bernard M. Gordon–MIT Engineering Leadership Program and is a prerequisite for continuing in the junior and senior follow-on. Further information on the program may be obtained from the department in which the student is registered or from Susann Luperfoy, executive director, Undergraduate Practice Opportunities Program, Room 1-193, 617-253-0055, mobile 617-921-3931, fax 617-253-8457, luperfoy@mit.edu, or from [http://upop.mit.edu/](http://upop.mit.edu/).

### Electives and Research Opportunities
A list of undergraduate electives in civil and environmental engineering may be obtained from the department. 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:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.050</td>
<td>Engineering Mechanics I</td>
</tr>
<tr>
<td>1.060</td>
<td>Engineering Mechanics II</td>
</tr>
<tr>
<td>1.101</td>
<td>Introduction to Civil and Environmental Engineering Design I</td>
</tr>
<tr>
<td>1.102</td>
<td>Introduction to Civil and Environmental Engineering Design II</td>
</tr>
<tr>
<td>1.035</td>
<td>Mechanics of Structures and Soils and</td>
</tr>
<tr>
<td>1.041</td>
<td>Engineering Systems Design or</td>
</tr>
<tr>
<td>1.036</td>
<td>Structural and Geotechnical Engineering Design</td>
</tr>
</tbody>
</table>

### 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).

### 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 1-281.

### 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. Designed for people with a bachelor’s degree in engineering (or related
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>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement (REST) Requirement [can be satisfied by 1.018J and 18.03 in the Departmental Program]</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement [can be satisfied by 1.101 and 1.102 in the Departmental Program]</td>
<td>2</td>
<td></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>Core</td>
<td></td>
</tr>
<tr>
<td>1.018 Ecology I: The Earth System, 12, REST, CI-M</td>
<td>8</td>
</tr>
<tr>
<td>1.020 Ecology II: Engineering for Sustainability, 12, Physics I (GIR), 18.03*</td>
<td></td>
</tr>
<tr>
<td>1.040 Engineering Mechanics I, 12, Physics I (GIR), Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td>1.100 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:
1.00 Introduction to Computers and Engineering Problem Solving, 12, REST; Calculus I (GIR) |
1.020 Uncertainty in Engineering, 12; Calculus II (GIR) |

Laboratory
1.101 Introduction to Civil and Environmental Engineering Design I, 6, 1/2 LAB; 1.018, 1.050 |
1.102 Introduction to Civil and Environmental Engineering Design II, 6, 1/2 LAB; 1.060, permission of instructor |

Restricted Electives
Students are required to take a coherent set of seven full subjects that meet a well-defined educational goal. These may be from within or outside the Department of Civil and Environmental Engineering. The electives must be approved by the student’s academic advisor and the undergraduate officer of the department.

84

Departmental Program Units That Also Satisfy the GIrS 36

Unrestricted Electives 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.

To satisfy the CI-M component of the Communication Requirement, students must take the department’s two CI-M subjects (1.013 and 1.018J) or, if appropriate, take one Course 1 CI-M subject and petition 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.

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 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, the mechanics of materials and structures, and transportation.

The program in environmental chemistry focuses on processes governing natural and man-made ecosystems. An understanding of field who want to enter or return to professional practice, the program prepares students for real-world engineering challenges. Our graduates routinely join leading engineering design firms, consulting companies, and government agencies. Some go on to pursue a PhD.

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, participants work in teams to develop and present solutions to realistic professional problems, including topics such as 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.

The distinctive element of the program is a professional practice experience for each specialty area; this experience is composed of a required group project and an individual, practice-oriented thesis.

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. MIT undergraduates may apply to the program at the end of their third year. Strong communication skills are expected.

For more information, see the Master of Engineering program description on the department’s website at http://cee.mit.edu/.
the mechanisms that regulate the flow of energy and cycling of materials through natural and man-made ecosystems is essential to address and avoid environmental problems. Water is one of the key media through which elements are transported within and between ecosystems, and it is also an important vehicle for the transport of anthropogenic toxic chemicals.

Graduate study in environmental fluid mechanics and coastal engineering offers education and research opportunities in many physical processes of water flow essential to the understanding, protection and improvement of the environment. The program emphasizes theoretical and experimental inquiries in both the laboratory and the field, and the development of models and strategies for practice. Interaction of physical processes with chemical and biological processes is also stressed.

Environmental microbiology focuses on microbial properties and processes that define the structure and function of natural and man-made ecosystems. Since the flow of energy and matter through the environment is often governed by microbial activities, it is essential to understand, predict and leverage them to both address and avoid environmental problems. 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. The foundation of our studies is grounded in microbial physiology, ecology, evolution and environmental science and engineering.

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 courses 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.

The graduate program in the mechanics of materials and structures seeks to advance fundamental understanding and develop 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.

The current research program includes projects on interface fracture and interfacial characterization in cementitious materials; development and behavior of high-performance concrete composites; development of fiber-reinforced high-strength silica fume concrete; micromechanics-based design of fiber-reinforced concrete composites; accelerated curing of concrete with microwave energy; use of reinforced plastic composites in repair and retrofitting concrete and steel structures; nondestructive evaluation of materials and structures; materials science and mechanics of natural and biological material (elasticity, deformation and fracture); and large-scale atomistic, molecular and multiscale modeling and supercomputing.

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 and the critical issues involved in meeting transportation needs in a sustainable way without negative impact on future generations. The Transportation program in CEE emphasizes the complexity of transportation and its dependence on the interaction of technology, operations, planning, management, and policy making. Increasingly our focus is shifting toward 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

Applicants do not need to have an undergraduate degree in civil engineering.

Numerous opportunities for graduate education in civil and environmental engineering exist for students with backgrounds in other branches of engineering, science, and certain social sciences. These arise through the growth of interdepartmental research and degree programs that bring people of diverse backgrounds together in search of solutions to major societal problems. Graduate students and faculty in the department have experience, for example, in economics, political science, sociology, architecture, urban and regional planning, management, biology, geology, chemistry, computer science, and oceanography.

Primary requirements for graduate study are a keen intellect combined with capability and interest in rigorous approaches to real problems. Students may make up deficiencies in prerequisites while pursuing a program of graduate study. Prerequisites for each subject are given in the subject descriptions.

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) or the Test of English as
CIVIL AND ENVIRONMENTAL ENGINEERING

a Foreign Language (TOEFL). More information about individual graduate programs can be obtained at 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 120 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.

The Department of Civil and Environmental Engineering also has a number of fellowships for first-year graduate students. Applicants are also 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/.

Interdepartmental Programs
Through its interdepartmental 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.

Master of Science in Transportation
The educational and research programs in transportation center around the interdepartmental Master of Science in Transportation (MST) program. This 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.

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.

The MST typically takes one and one-half to two years to complete. Students in the MST program must complete a block of two required core subjects and at least three additional transportation or related subjects, in addition to the master’s thesis. 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.

For more information, see the MST program description on the department’s website at http://cee.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 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 SM in management or an MBA, and an SM from a participating engineering department. The program is offered jointly through the MIT Sloan School of Management and the School of Engineering. For more information, see the program description under Engineering Systems Division or visit http://lgo.mit.edu/.

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 academic policies and programs of the department may be obtained by writing to or visiting the Academic Programs Office, Room 1-281, 617-253-9723, fax 617-258-6775, 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 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 recently renovated four-story structure containing about 31,000 square feet of classrooms, teaching and research laboratories, machine shops, computer facilities, and offices. Approximately 60 graduate students and 18 faculty members 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 GCs, a GC-MS, LC-MS, and several HPLCs, two flame AAs, a graphite furnace AA, alpha and gamma spectrometry counting systems, scintillation counters, several flow cytometers, a laser light scattering instrument, and incubators, a cold room, and several -80°C freezers. One laboratory, recently renovated, is a dedicated teaching facility for environmental engineering and 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. A new, state-of-the-art inductively coupled plasma spectrometer was recently acquired. Computer facilities include a 100-processor Beowulf (parallel computing) cluster, among other computer clusters.
Building 1
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 90 graduate students and 20 faculty members and research staff.

Research activities focus on three major areas: geotechnical engineering and geomechanics, the mechanics of materials and structures, 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 that provides facilities to process, fabricate, and form 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, an environmental chamber, 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.

Building 1 offers diverse and advanced computational facilities, including a large Linux cluster, a large Athena cluster, and networked Sun, Digital, and Windows workstations. The computing facilities feature various software development packages, visualization workstations, and an extensive set of structural, project management, geotechnical and materials analysis programs such as SAP, STRUDL, PLAXIS, MATLAB, AUTOCAD, FORTRAN, Primavera, Crystal Ball, ADINA, and ABAQUS, as well as molecular dynamics applications for the analysis of nanomechanics of natural and biological structures.

Center for Environmental Sensing and Modeling
The Center for Environmental Sensing and Modeling is a collaborative research program headed by Professor Andrew Whittle and involving many faculty members from CEE and other departments 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.

Laboratory for Energy and the Environment
The Education Program of the Laboratory for Energy and the Environment (LTEE) is dedicated to enhancing environmental literacy and deepening multidisciplinary environmental knowledge, particularly among the leaders of tomorrow’s science and technology communities. The program cultivates the capacity of learners at all levels to both understand and respond effectively to the challenges of sustainability. More information about LTEE is available at http://ltee.mit.edu/.

Center for Environmental Health Sciences
Historically, the Department of Civil and Environmental Engineering has had strong ties to the Center for Environmental Health Sciences in teaching and research activities related to understanding the role of chemical and biological agents in the environment as causes of human disease. More information about the center is available under Interdisciplinary Research and Study in Part 3.

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 the ESI website at http://esi.mit.edu/.

Center for Global Change Science
The 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 to investigate climate phenomena, the linkages among them, and their potential feedbacks in a changing climate. The CGCS provides opportunities for close cooperation in education and research between faculty, research scientist staff, and students in the Department of Civil and Environmental Engineering, the Department of Earth, Atmospheric and Planetary Sciences, MIT’s Energy Initiative, and other MIT departments. The major research initiatives in the CGCS are the MIT Climate Modeling Initiative, the Advanced Global Atmospheric Gases Experiment, and the Joint Program on the Science and Policy of Global Change. More information about the center is available under Interdisciplinary Research and Study in Part 3 or at the CGCS website, http://mit.edu/cgcs/.

Faculty and Teaching Staff
Patrick Jaillet, PhD
Edmund K. Turner Professor of Civil and Environmental Engineering
Ole Secher Madsen, ScD
Donald and Martha Harleyman Professor
Professor of Civil and Environmental Engineering

Professors
Cynthia Barnhart, PhD
Professor of Civil and Environmental Engineering and Engineering Systems
Associate Dean for Academic Affairs, School of Engineering
Moshe Emanuel Ben-Akiva, PhD
Edmund K. Turner Professor of Civil and Environmental Engineering
Rafael Luis Bras, ScD
Professor of Civil and Environmental Engineering
(On leave)
Oral Buyukozturk, PhD
Professor of Civil and Environmental Engineering
Sallie W. Chisholm, PhD
Lee and Geraldine Martin Professor of Environmental Studies
Professor of Civil and Environmental Engineering and Biology
Jerome Joseph Connor, Jr., ScD
Professor of Civil and Environmental Engineering
Edward F. DeLong, PhD
Professor of Civil and Environmental Engineering and Biological Engineering
Associate Member, Broad Institute
Richard Lawrence de Neufville, PhD
Professor of Civil and Environmental Engineering and Engineering Systems
Herbert Heinrich Einstein, ScD
Professor of Civil and Environmental Engineering
Elfatih A. B. Eltahir, ScD
Professor of Civil and Environmental Engineering
Dara Entekhabi, PhD
Bacardi and Stockholm Water Foundation Professor
Professor of Civil and Environmental Engineering
Lorna Jane Gibson, PhD
Matoula S. Salapatas Professor of Materials Science and Engineering
Professor of Civil and Environmental Engineering and Mechanical Engineering
Philip Michael T. Gschwandt, PhD
Ford Professor of Engineering
Professor of Civil and Environmental Engineering
Harold Field Hemond, PhD
William E. Leonhard Professor of Engineering
Professor of Civil and Environmental Engineering
Eduardo Kausel, PhD
Professor of Civil and Environmental Engineering
Richard C. Larson, PhD
Mitsui Professor
Professor of Civil and Environmental Engineering and Engineering Systems
Steven Richard Lerman, PhD
Class of 1922 Professor
Professor of Civil and Environmental Engineering
Vice Chancellor and Dean for Graduate Education
David Hunter Marks, PhD
Morton and Claire Goulder Family Professor
Professor of Civil and Environmental Engineering and Engineering Systems
Dennis B. McLaughlin, PhD
H. M. King Bhumipol Professor
Professor of Civil and Environmental Engineering
Chiang Chung Mei, PhD
Ford Professor of Engineering
Professor of Civil and Environmental Engineering
Fred Moavenzadeh, PhD
James Mason Crafts Professor
Professor of Civil and Environmental Engineering and Engineering Systems
Heidi M. Nepf, PhD
Professor of Civil and Environmental Engineering
MacVicar Faculty Fellow
Amedeo Rodolfo Odoni, PhD
Professor of Aeronautics and Astronautics and Civil and Environmental Engineering
Martin F. Polz, PhD
Professor of Civil and Environmental Engineering
Daniel Roos, PhD
Professor of Engineering Systems and Civil and Environmental Engineering
Yossi Sheffi, PhD
Professor of Civil and Environmental Engineering and Engineering Systems
David Simchi-Levi, PhD
Professor of Civil and Environmental Engineering and Engineering Systems
Joseph Martin Sussman, PhD
JR East Professor
Professor of Civil and Environmental Engineering and Engineering Systems
Franz-Josef Ulm, PhD
Professor of Civil and Environmental Engineering
Daniele Veneziano, PhD
Professor of Civil and Environmental Engineering
Andrew J. Whittle, PhD
Professor of Civil and Environmental Engineering
John Williams, PhD
Professor of Civil and Environmental Engineering and Engineering Systems
Nigel Henry Moir Wilson, PhD
Professor of Civil and Environmental Engineering

Associate Professors
Charles F. Harvey, PhD
Associate Professor of Civil and Environmental Engineering

Assistant Professors
Eric J. Alm, PhD
Assistant Professor of Civil and Environmental Engineering and Biological Engineering
Associate Member, Broad Institute
Markus J. Buehler, PhD
Esther and Harold E. Edgerton Career Development Professor
Assistant Professor of Civil and Environmental Engineering
Ruben Juanes, PhD
Atlantic Richfield Career Development Professorship
Assistant Professor of Civil and Environmental Engineering
Jesse Kroll, PhD
Assistant Professor of Civil and Environmental Engineering

Senior Lecturers
E. Eric Adams, PhD
John T. Germaine, PhD
Joseph Martin Sussman, PhD
JR East Professor
Professor of Civil and Environmental Engineering and Engineering Systems
Franz-Josef Ulm, PhD
Professor of Civil and Environmental Engineering
Daniele Veneziano, PhD
Professor of Civil and Environmental Engineering
Andrew J. Whittle, PhD
Professor of Civil and Environmental Engineering
John Williams, PhD
Professor of Civil and Environmental Engineering and Engineering Systems

Lecturers
Charles C. Caldart, JD
Christopher Cassa, PhD
Sheila Frankel, MA
V. Judson Harward, PhD
Lucy Jen, PhD
Paul Kassabian, MS
Mikel Murga, MS
Lisa J. O’Donnell, MS
Derish Wolf, MBA

Research Staff

Senior Research Engineer
E. Eric Adams, PhD

Senior Research Associate
John T. Germaine, PhD

Principal Research Engineer
Earle Williams, PhD

Research Engineer
John Eppley, PhD
John MacFarlane, SM

Research Associate
Sheila L. Frankel, MA

Research Scientists
Katherine Huang, SM
Asunción Martínez, PhD
Marcia Osborne, PhD

Professors Emeriti
Peter Sturges Eagleson, ScD
Edmund K. Turner Professor of Civil and Environmental Engineering, Emeritus

Lynn Walter Gelhar, PhD
Professor of Civil and Environmental Engineering, Emeritus

Robert Joseph Hansen, ScD
Professor of Civil and Environmental Engineering, Emeritus

Charles Cushing Ladd, ScD
Edmund K. Turner Professor of Civil and Environmental Engineering, Emeritus

Thomas William Lambe, ScD
Edmund K. Turner Professor of Civil and Environmental Engineering, Emeritus

Robert Daniel Logcher, ScD
Professor of Civil and Environmental Engineering, Emeritus

Frank Edward Perkins, ScD
Professor of Civil and Environmental Engineering, Emeritus

Robert Van Duyne Whitman, ScD
Professor of Civil and Environmental Engineering, Emeritus
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-P 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-
nating in written and oral reports. Normally, the thesis for the Master of Engineering degree will provide this experience for students receiving both degrees simultaneously.

Much flexibility is built into the elective structure for the department’s programs. Some further variations in requirements are routinely permitted, while still others will be considered on an individual basis. Approval of requests for substantial changes may be granted to well-prepared students whose proposed programs provide an integrated approach to a well-defined educational objective and are comparable with the listed curricula in breadth and depth. Changes affecting the required core portion of each curriculum, however, are rarely approved.

Programs leading to the professional five-year Master of Engineering degree or to the preprofessional four-year Bachelor of Science degrees can easily be arranged to be identical through the junior year. At the end of the junior year, students with strong academic records will be offered the opportunity to continue through the five-year master’s program. A student in the Master of Engineering program must be registered as a graduate student for at least one regular (non-summer) term. To remain in the program and to receive the Master of Engineering degree, students will be expected to maintain strong academic records. Admission to the Master of Engineering program is open only to undergraduate students who have completed their junior year in the Department of Electrical Engineering and Computer Science at MIT. Students with other preparation seeking a Master of Science degree will be expected to complete their junior year Master of Engineering degree or to the five-year GIM.

The fifth year of study toward the Master of Engineering degree can be supported by a graduate fellowship, a fellowship, or a graduate assistantship described later in this section, and an award such as a National Science Foundation Fellowship, a fellowship, or 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 academic credit for their participation in the teaching or research

| 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>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</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><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).

### PLU\& Departmental Program

<table>
<thead>
<tr>
<th>Subject names below are followed by credit units and by prerequisites, if any (corequisites in italics).</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Required Subjects</strong></td>
<td>36</td>
</tr>
<tr>
<td>6.01 Introduction to EECS I, 12, 1/2 LAB; Physics II (GIR)</td>
<td>132–144</td>
</tr>
<tr>
<td>6.02 Introduction to EECS II, 12, 1/2 LAB; 6.01, 18.03*</td>
<td></td>
</tr>
<tr>
<td><strong>Restricted Electives</strong></td>
<td></td>
</tr>
<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>and</td>
<td></td>
</tr>
<tr>
<td>(b) Either 6.041 (alternatively 18.440) or 6.042J. Students in Course 6-1 must select 6.041 (or 18.440); students in Course 6-3 must select 6.042J.</td>
<td></td>
</tr>
<tr>
<td>2. One department laboratory:</td>
<td></td>
</tr>
<tr>
<td>One subject selected from the undergraduate laboratory subjects 6.100–6.182 or a departmental list of CS laboratory subjects; students in Course 6-3 must select a CS laboratory subject.</td>
<td></td>
</tr>
<tr>
<td>Students in Course 6-1 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).</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: 6.002, 6.003, 6.004, 6.007, 6.101, 6.102, 6.103, 6.104, 6.105, 6.106.</td>
<td></td>
</tr>
<tr>
<td>(b) Students in Course 6-3 must take the three subjects in the CS foundation 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, 6.014, 6.015, 6.016, 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>
</tr>
<tr>
<td>(d) 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>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, 6.021J.</td>
<td></td>
</tr>
<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, 6.011J, 6.015, 6.016, 6.017, 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>
</tr>
<tr>
<td>2. Two subjects from a departmental list of advanced undergraduate subjects.</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, 6.031, 6.101, 6.111, 6.115, 6.121J, 6.131, 6.141, 6.152, 6.161, 6.182, or 6.805. 6.UAT/6.UAP constitutes the second CI-M.</td>
<td></td>
</tr>
</tbody>
</table>

### Departmental Program Units That Also Satisfy the GIRs

| (36) |

### Unrestricted Electives

| 48 |

### Total Units Beyond the GIRs Required for SB Degree

| 180–192 |

### Notes

*Alternate prerequisites are listed in the subject descriptions.

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).
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.

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.

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-P, which is the 6-A version of the department’s five-year 6-P Master of Engineering degree program. 6-P 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 Electromagnetic and Electronic Systems, 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.

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>
<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 (satisfied by the mathematics requirement in the Departmental Program)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement (satisfied by 6.01 and 6.02 together in the Departmental Program)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total GIR Subjects Required for the SB and MEng Degrees</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).

<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></td>
</tr>
<tr>
<td>Required Subjects</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>6.01 Introduction to EECS 1, 12, 1/2 LAB; Physics II (GIR)</td>
<td>6.02 Introduction to EECS II, 12, 1/2 LAB, 6.01, 18.03*</td>
<td>6.10J and 6.1UAP Undergraduate Advanced Project, 12</td>
</tr>
<tr>
<td>6.15M MEng Program Thesis, 24**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restricted Electives</td>
<td>198–210</td>
<td></td>
</tr>
<tr>
<td>1. Two mathematics subjects (also satisfies REST requirement):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Either 18.03 or 18.06 (alternatively 18.700)</td>
<td>(b) Either 6.044 (alternatively 18.440) or 6.044J or both. Students in Course 6-1 for their bachelor’s degree must select 6.044J (or 18.440); students in Course 6-3 for their bachelor’s degree must select 6.044J.</td>
<td></td>
</tr>
<tr>
<td>2. One department laboratory:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>One subject selected from the undergraduate laboratory subjects 6.100-6.182 or a departmental list of CS laboratories; 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 department laboratory requirement.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Three/four foundation subjects:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Students in Course 6-1 must take three subjects from the EE foundation list: 6.002, 6.003, 6.004, 6.007.</td>
<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 (6.002-6.007), 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).</td>
<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, 6.021J.</td>
<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, 6.021J, 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>5. Two subjects from a departmental list of advanced undergraduate subjects.</td>
<td></td>
</tr>
<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>7. Two subjects from a restricted departmental list of mathematics, science, and engineering electives.</td>
<td></td>
</tr>
<tr>
<td>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, 6.115, 6.121J, 6.131, 6.141, 6.152J, 6.161, 6.182, or 6.805, 6.1UAT/ 6.1UAP constitutes the second CI-M.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Departmental Program Units That Also Satisfy the GIRs</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Unrestricted Electives</td>
<td>48</td>
<td></td>
</tr>
</tbody>
</table>

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.
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.

Notes

*Alternate prerequisites are listed in the subject description.
**6-PA Program requires performance of thesis at company location.

Notes on Master of Engineering and Bachelor's Degree Programs

The Master of Engineering program builds on the bachelor's degree program selected by the student (6-1, 6-2, or 6-3), with restricted elective categories 6 and 7 and the MEng thesis (6.ThM).

The subjects required under restricted elective category 6 are selected with departmental review and approval to ensure that the combination of these with the two advanced undergraduate subjects under restricted elective category 5 includes at least 36 units in a distinct and appropriate area of graduate concentration.

The Master of Engineering in Electrical Engineering and Computer Science is only awarded to students who have received, or are simultaneously receiving, one of the three bachelor's degrees. Students who receive the Master of Engineering degree after having obtained one of the three bachelor's degrees must fulfill the requirements for Course 6-P as described above.

For further details on all EECS programs, visit http://www.eecs.mit.edu/acad.html.
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.

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://web.mit.edu/cdo-program/index.html.

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.
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 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 SM in management or an MBA, and an SM from a participating engineering department. The program is offered jointly through the MIT Sloan School of Management and the School of Engineering. For more information, see the program description under Engineering Systems Division or visit http://lgo.mit.edu/.

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://tppserver.mit.edu/.

Faculty and Staff

Faculty and Teaching Staff

William Eric Leifur Grimson, PhD
Bernard M. Gordon Professor of Medical Engineering
Department Head
Duane S. Boning, PhD
Professor of Electrical Engineering and Computer Science
Associate Head
Srinivas Devadas, PhD
Professor of Electrical Engineering and Computer Science
Associate Head
Dennis M. Freeman, PhD
Professor of Electrical Engineering
MacVicar Faculty Fellow
Education Officer
Christopher J. Terman, PhD
Senior Lecturer
Undergraduate Officer
Terry Philip Orlando, PhD
Professor of Electrical Engineering
Graduate Officer
Markus Zahn, ScD
Thomas and Gerd Perkins Professor of Electrical Engineering
Director, 6-A Internship Program

Professors

Harold Abelson, PhD
Class of 1922 Professor of Computer Science and Engineering
Anant Agarwal, PhD
Professor of Computer Science and Engineering
Associate Director, Computer Science and Artificial Intelligence Laboratory
Akintunde I. Akinwande, PhD
Professor of Electrical Engineering
Saman P. Amarasinghe, PhD
Professor of Computer Science and Engineering
Dimitri A. Antoniadis, PhD
Ray and Maria Stata Professor of Electrical Engineering
Arvind, PhD
Charles W. and Jennifer C. Johnson Professor of Computer Science and Engineering
Arthur Bernard Baggeroer, ScD
Ford Professor of Engineering and Mechanical Engineering
Hari Balakrishnan, PhD
Professor of Computer Science and Engineering
Timothy Berners-Lee
3COM Founders Professor of Engineering
Abraham Bers, ScD
Professor of Electrical Engineering
Dimitri P. Bertsekas, PhD
McAfee Professor of Electrical Engineering
Robert Cregar Berwick, PhD
Professor of Computer Science and Engineering and Computational Linguistics
Sangeeta Bhatia, MD, PhD
Professor of Electrical Engineering and Health Sciences and Technology
Howard Hughes Medical Investigator
Associate Member, Broad Institute
Louis Benjamin Daniel Braida, PhD
Henry Ellis Warren Professor of Electrical Engineering and Health Sciences and Technology
Rodney Allen Brooks, PhD
Panasonic Professor of Computer Science and Engineering
Vincent W. S. Chan, PhD
Joan and Irwin M. Jacobs Professor of Electrical Engineering
Anantha P. Chandrakasan, PhD
Joseph F. and Nancy P. Keithley Professor of Electrical Engineering
Director, Microsystems Technology Laboratories
Isaac L. Chuang, PhD
Professor of Electrical Engineering
Munther A. Dahleh, PhD
Professor of Electrical Engineering
Randall Davis, PhD
Professor of Computer Science and Engineering
Paul Livingstone Penfield, Jr., ScD
Professor of Electrical Engineering

Rajeev J. Ram, PhD
Professor of Electrical Engineering
Associate Director, Research Laboratory of Electronics

L. Rafael Reif, PhD
Fariborz Maseeh Professor of Emerging Technology
Provost

Martin C. Rinard, PhD
Professor of Computer Science and Engineering

Ronald Linn Rivest, PhD
Andrew and Erna Viterbi Professor of Computer Science and Engineering

James Kerr Roberge, ScD
Professor of Electrical Engineering

Ronitt Rubinfeld, PhD
Professor of Computer Science and Engineering

Daniela L. Rus, PhD
Professor of Computer Science and Engineering
Associate Director, Computer Science and Artificial Intelligence Laboratory

Herbert H. Sawin, PhD
Professor of Chemical Engineering and Electrical Engineering

Joel E. Schindall, PhD
Bernard M. Gordon Professor of the Practice
Associate Director, Laboratory for Electromagnetic and Electronic Systems

Martin A. Schmidt, PhD
Professor of Electrical Engineering
Associate Provost

Jeffrey Howard Shapiro, PhD
J. A. Stratton Professor of Electrical Engineering
Director, Research Laboratory of Electronics

Henry I. Smith, PhD
Professor of Electrical Engineering

Charles G. Sodini, PhD
Clarence Joseph LeBel Professor of Electrical Engineering

David Hudson Staelin, ScD
Professor of Electrical Engineering

Kenneth Noble Stevens, ScD
Professor of Electrical Engineering and Health Sciences

Madhu Sudan, PhD
Fujitsu Professor of Computer Science and Engineering
Associate Director, Computer Science and Artificial Intelligence Laboratory

Gerald Jay Sussman, PhD
Panasonic Professor of Electrical Engineering

Peter Szolovits, PhD
Professor of Computer Science and Engineering
and Health Sciences and Technology

Seth Teller, PhD
Professor of Computer Science and Engineering

Bruce Tidor, PhD
Professor of Electrical Engineering

John N. Tsitsiklis, PhD
Clarence Joseph LeBel Professor of Electrical Engineering and Computer Science

George C. Verghese, PhD
Professor of Electrical Engineering

Stephen Ashley Ward, PhD
Professor of Computer Science and Engineering

Cardinal Warde, PhD
Professor of Electrical Engineering

Jacob K. White, PhD
Cecil H. Green Professor of Electrical Engineering

Alan Steven Willsky, PhD
Edwin S. Webster Professor of Electrical Engineering

Patrick Henry Winston, PhD
Ford Professor of Engineering

Gregory W. Wornell, PhD
Professor of Electrical Engineering

John L. Wyatt, Jr., PhD
Professor of Electrical Engineering

Victor W. Zue, ScD
Delta Electronics Research Professor of Electrical Engineering and Computer Science
Director, Computer Science and Artificial Intelligence Laboratory

Associate Professors

Elfar Adalsteinsson, PhD
Associate Professor of Electrical Engineering and Computer Science and Health Sciences and Technology

Marc A. Baldo, PhD
Associate Professor of Electrical Engineering

Regina A. Barzilay, PhD
Associate Professor of Computer Science and Engineering

Karl K. Berggren, PhD
Emanuel E. Landsman Associate Professor of Electrical Engineering and Computer Science

Vladimir Bulovic, PhD
Associate Professor of Electrical Engineering

Michael J. Collins, PhD
Associate Professor of Computer Science and Engineering

Luca Daniel, PhD
Emanuel E. Landsman Career Development Associate Professor of Electrical Engineering

Erik D. Demaine, PhD
Associate Professor of Computer Science and Engineering

Polina Golland, PhD
Distinguished Alumnus 1964 Career Development Associate Professor of Computer Science and Engineering

Vivek K. Goyal, PhD
Esther and Harold Edgerton Career Development Associate Professor of Electrical Engineering and Computer Science

Peter L. Hagelstein, PhD
Associate Professor of Electrical Engineering

Associate Professors

Elfar Adalsteinsson, PhD
Associate Professor of Electrical Engineering and Computer Science and Health Sciences and Technology

Marc A. Baldo, PhD
Associate Professor of Electrical Engineering

Regina A. Barzilay, PhD
Associate Professor of Computer Science and Engineering

Karl K. Berggren, PhD
Emanuel E. Landsman Associate Professor of Electrical Engineering and Computer Science

Vladimir Bulovic, PhD
Associate Professor of Electrical Engineering

Michael J. Collins, PhD
Associate Professor of Computer Science and Engineering

Luca Daniel, PhD
Emanuel E. Landsman Career Development Associate Professor of Electrical Engineering

Erik D. Demaine, PhD
Associate Professor of Computer Science and Engineering

Polina Golland, PhD
Distinguished Alumnus 1964 Career Development Associate Professor of Computer Science and Engineering

Vivek K. Goyal, PhD
Esther and Harold Edgerton Career Development Associate Professor of Electrical Engineering and Computer Science

Peter L. Hagelstein, PhD
Associate Professor of Electrical Engineering
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>David Jacob Epstein, ScD</td>
<td>Professor of Electrical Engineering, Emeritus</td>
</tr>
<tr>
<td>Shaoul Ezekiel, ScD</td>
<td>Professor of Aeronautics and Astronautics and Electrical Engineering, Emeritus</td>
</tr>
<tr>
<td>Robert Mario Fano, ScD</td>
<td>Ford Professor of Engineering, Emeritus</td>
</tr>
<tr>
<td>Lawrence Samuel Frishkopf, PhD</td>
<td>Professor of Electrical and Bioengineering, Emeritus</td>
</tr>
<tr>
<td>Harry Constantine Gatos, PhD</td>
<td>Professor of Molecular Engineering and Electronic Materials, Emeritus</td>
</tr>
<tr>
<td>Leonard A. Gould, ScD</td>
<td>Professor of Electrical Engineering, Emeritus</td>
</tr>
<tr>
<td>Carl Eddie Hewitt, PhD</td>
<td>Associate Professor of Computer Science and Engineering, Emeritus</td>
</tr>
<tr>
<td>Robert Spayde Kennedy, ScD</td>
<td>Professor of Electrical Engineering, Emeritus</td>
</tr>
<tr>
<td>Francis Fan Lee, PhD</td>
<td>Professor of Electrical Engineering and Computer Science, Emeritus</td>
</tr>
<tr>
<td>Jerome Ysrael Lettvin, MD</td>
<td>Professor of Electrical and Bioengineering and Communications Physiology, Emeritus</td>
</tr>
<tr>
<td>Alan Louis McWhorter, ScD</td>
<td>Professor of Electrical Engineering, Emeritus</td>
</tr>
<tr>
<td>Frederic Richard Morgenthaler, PhD</td>
<td>Professor of Electrical Engineering, Emeritus</td>
</tr>
<tr>
<td>Walter E. Morrow, Jr., MS</td>
<td>Professor of Electrical Engineering, Emeritus</td>
</tr>
<tr>
<td>George Woodman Pratt, Jr., PhD</td>
<td>Professor of Electrical Engineering, Emeritus</td>
</tr>
<tr>
<td>Jack Philip Ruina, DEE</td>
<td>Professor of Electrical Engineering, Emeritus</td>
</tr>
<tr>
<td>Jerome H. Saltzer, ScD</td>
<td>Professor of Computer Science and Engineering, Emeritus</td>
</tr>
<tr>
<td>William Francis Schreiber, PhD</td>
<td>Professor of Electrical Engineering, Emeritus</td>
</tr>
<tr>
<td>Campbell Leach Searle, SM</td>
<td>Professor of Electrical Engineering, Emeritus</td>
</tr>
<tr>
<td>Stephen David Senturia, PhD</td>
<td>Professor of Electrical Engineering, Emeritus</td>
</tr>
<tr>
<td>William McConway Siebert, ScD</td>
<td>Ford Professor of Engineering, Emeritus</td>
</tr>
<tr>
<td>Arthur Clarke Smith, PhD</td>
<td>Professor of Electrical Engineering, Emeritus</td>
</tr>
<tr>
<td>Richard Douglas Thornton, ScD</td>
<td>Professor of Electrical Engineering, Emeritus</td>
</tr>
<tr>
<td>Thomas Fischer Weiss, PhD</td>
<td>Professor of Electrical and Bioengineering, Emeritus</td>
</tr>
<tr>
<td>David Calvin White, PhD</td>
<td>Ford Professor of Engineering, Emeritus</td>
</tr>
<tr>
<td>Gerald Loomis Wilson, ScD</td>
<td>Vannevar Bush Professor of Electrical and Mechanical Engineering, Emeritus</td>
</tr>
<tr>
<td>John McReynolds Wozencraft, PhD</td>
<td>Professor of Electrical Engineering, Emeritus</td>
</tr>
</tbody>
</table>
The MIT Engineering Systems Division (ESD) embraces complex, large-scale problems by integrating approaches based on engineering, management, and the 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; to serve as a model to broaden engineering education generally; and to expand the scope and practice of engineering. To help accomplish these goals, ESD actively develops innovative relationships with industry and government through collaborative global research projects and long-distance educational programs.

Engineering systems are increasingly difficult as they 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 a more integrative approach in which engineering systems professionals view the technological system as part of a larger whole. While the ESD approach is broader, 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 these systems.

The Engineering Systems Division encompasses five master’s programs: the Technology and Policy Program, the Master of Engineering in Logistics, the Leaders for Global Operations program, the System Design and Management program, 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 Technology, Policy, and Industrial Development, the Center for Transportation and Logistics, the Center for Engineering Systems Fundamentals, 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 Technology, Policy, and Industrial Development; 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 at [http://www.ielts.org/](http://www.ielts.org/) for the International English Language Testing System (IELTS) exam, academic format, and achieving a score of 7.5 or better. In areas where the IELTS is not available, the Test of English as a Foreign Language (TOEFL) is an acceptable substitute, if a score equal to or higher than 255 for the computer-based test, 103 for the internet-based test, and 610 for the paper-based test, is achieved. Registration forms for this test can be obtained by contacting toefl@ets.org. Information about the Graduate Record Examinations (GRE) and Graduate Management Admissions Test (GMAT) is available at gre-info@ets.org and gmat@ets.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/).

All programs except the Master of Engineering in Logistics may offer student fellowships or graduate research or teaching assistantships. Information about these should be obtained directly from the individual programs.

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. 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, political 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.132 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 January 10. 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.

Master of Engineering in Logistics
The Master of Engineering in Logistics (MLOG) 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 MLOG degree 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, MLOG 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 MLOG 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 TOEFL exam and achieve a score equal to or higher than 255 (610 for the paper-based version, or 103 for the internet-based version).

The MLOG curriculum begins in September. There are two admission rounds. The round 1 deadline is January 18, 2010; the round 2 deadline is April 5, 2010. Applications should be sent to the MLOG Admissions Office. For additional information, contact the MLOG Admissions Office, Room E40-355, 617-324-6564, mlog@mit.edu, or visit http://web.mit.edu/mlog/.

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.72J 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, MIT Sloan School of Management, and more than 20 corporations, 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 master’s degrees, an SM from ESD (or another participating engineering department) and an MBA or SM from the MIT Sloan School of Management. In addition to ESD, seven engineering master’s programs participate in LGO: Aeronautics and Astronautics, Biological Engineering, Chemical Engineering, Civil and Environmental Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, and Mechanical Engineering.

The 24-month, dual-degree LGO program integrates engineering and management disciplines and emphasizes leadership, teamwork, management of change processes, and learning by doing. The rigorous curriculum is developed and taught by faculty from both schools. It includes a 6.5-month internship on-site research. The coursework and research culminate in a single thesis.


To complete the requirements for the LGO program, students also take engineering subjects in product development as well as additional electives in management and their engineering concentration.

The LGO academic program begins in June. Students are generally required to have at least two years of full-time work experience. Applications are due in December and can be made either through a participating engineering department or through 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 SM programs that are part of ESD (i.e., the Technology and Policy, Master of Engineering in Logistics, 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/academic/sm_phd/faqs.html. Admissions decisions are made once a year. Applications are due January 10.

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 her thesis, 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 generally 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 Research Methods, and an applied engineering systems subject. For details on the program, see http://esd.mit.edu/phyd/.

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. Current MIT students wishing to apply to the ESD PhD program should first discuss their interests with ESD
faculty members in their field of interest and obtain their support. All applications for the cohort forming in September are due January 10. For additional information, please visit the Frequently Asked Questions about Admissions at http://esd.mit.edu/academic/sm_phd_faqs.html.

Human-Systems Engineering Track
The new 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.756J Statistical Methods in Experimental Design or ESD 86 Models, Data, and Inference for Socio-Technical Systems
- ESD.774J 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 Center for Technology, Policy, and Industrial Development 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.

Center for Technology, Policy, and Industrial Development
MIT’s Center for Technology, Policy, and Industrial Development (CTPID) is an interdisciplinary research and educational center addressing global technology and policy issues through sustained partnerships with industry, government, and academia. These partnerships are aimed at supporting global economic growth and advancing policies that preserve the environment and benefit society at large.

Center programs include the Ford-MIT Alliance, IMVP, Lean Advancement Initiative, Lean Sustainment Initiative, Information Quality Program (MIT IQ), Materials Systems Laboratory, and the Technology and Law Program.

For further information on CTPID and its programs, see Interdisciplinary Research and Study in Part 3.

Center for Transportation & Logistics
For more than 30 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 MIT AgeLab.

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
- Supply Chain 2020: The Future of the Supply Chain
- Supply Chain Innovation in Emerging Markets
- Supply Chain Security
- Supply Chain Network Risk Management
- AgeLab

MIT CTL research in the area of transportation spans all of its aspects and modes. Research projects include:

- New England University Transportation Center
- MIT/Transit Professional Development Program
- MIT Program in Intelligent Transportation Systems
- National Center of Excellence for Aviation Operations Research

The AgeLab brings together a multidisciplinary team from across MIT and around the world to conduct research on health and wellness, transportation, and longevity planning to develop new ideas and technologies that improve the quality of life for older adults and the people who care for them.

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.

MIT CTL’s Master of Engineering in Logistics (MLOG) program attracts business professionals from across the globe to participate in its intensive logistics and supply chain management program. The MLOG 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 are also 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 programs, should write to Jarrod Goentzel, MIT Center for Transportation and Logistics, Room E40-211A, goentzel@mit.edu, or visit [http://web.mit.edu/ctl/](http://web.mit.edu/ctl/).

Students interested in the Master of Science in Transportation program administered through the Department of Civil and Environmental Engineering should contact Nigel Wilson, Room 1-238, nhmw@mit.edu. 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.

**Faculty and Staff**

**Faculty and Teaching Staff**

Yossi Sheffi, PhD  
Professor of Engineering Systems and Civil and Environmental Engineering  
Director, MIT Center for Transportation and Logistics  
Director, Engineering Systems Division

Olivier L. de Weck, PhD  
Associate Professor of Aeronautics and Astronautics and Engineering Systems  
Associate Director, Engineering Systems Division

**Professors**

Thomas J. Allen, PhD  
Howard W. Johnson Professor of Management, Emeritus  
Professor of Engineering Systems, Emeritus  
Codirector, LGO and SDM Programs

George E. Apostolakis, PhD  
Korea Electric Power Professor of Nuclear Science and Engineering  
Professor of Engineering Systems

Cynthia Barnhart, PhD  
Professor of Civil and Environmental Engineering and Engineering Systems  
Codirector, Operations Research Center  
Associate Dean for Academic Affairs, School of Engineering

John Carroll, PhD  
Morris A. Adelman Professor of Management  
Professor of Engineering Systems  
Codirector, Lean Advancement Initiative

Joel Philip Clark, ScD  
Professor of Materials Systems and Engineering Systems

Edward F. Crawley, PhD  
Professor of Aeronautics and Astronautics and Engineering Systems  
Ford Professor of Engineering

Michael Cusumano, PhD  
Sloan Management Review Distinguished Professor of Management  
Professor of Engineering Systems

Richard de Neufville, PhD  
Professor of Civil and Environmental Engineering and Engineering Systems

Thomas Waddy Eagar, ScD  
Thomas Lord Professor of Materials Engineering and Engineering Systems

Steven D. Eppinger, ScD  
General Motors LFM Professor of Management Science  
Professor of Engineering Systems  
Deputy Dean, MIT Sloan School of Management

Charles Fine, PhD  
Chrysler LFM Professor of Management  
Professor of Engineering Systems

Stephen C. Graves, PhD  
Abraham J. Siegel Professor of Management  
Professor of Engineering Systems

John Hansman, PhD  
Professor of Aeronautics and Astronautics and Engineering Systems  
Head, Division of Humans and Automation  
Director, International Center for Air Transportation

David Edgar Hardt, PhD  
Ralph E. and Eloise F. Cross Professor of Mechanical Engineering  
Professor of Engineering Systems

Daniel Hastings, PhD  
Professor of Aeronautics and Astronautics and Engineering Systems  
Dean for Undergraduate Education

Thomas Anton Kochan, PhD  
George Maverick Bunker Professor of Management  
Professor of Engineering Systems

Paul A. Lagacé, PhD  
Professor of Aeronautics and Astronautics and Engineering Systems  
MacVicar Faculty Fellow

Richard Larson, PhD  
Mitsui Professor of Civil and Environmental Engineering and Engineering Systems  
Director, Center for Engineering Systems Fundamentals

Nancy Leveson, PhD  
Professor of Aeronautics and Astronautics and Engineering Systems

Seth Lloyd, PhD  
Professor of Mechanical Engineering and Engineering Systems
Stuart Madnick, PhD  
John Norris Maguire Professor of Information Technology and Engineering Systems  
Codirector, PROFIT Program  
David Hunter Marks, PhD  
Morton and Claire Goulder Family Professor of Civil and Environmental Engineering and Engineering Systems  
David A. Mindell, PhD  
Frances and David Dibner Professor of the History of Engineering and Manufacturing (STS)  
Professor of Engineering Systems  
MacVicar Faculty Fellow  
Director, Science, Technology, and Society Program  
Sanjoy Mitter, PhD  
Professor of Electrical Engineering and Engineering Systems  
Fred Moavenzadeh, PhD  
James Mason Crafts Professor  
Professor of Civil and Environmental Engineering and Engineering Systems  
Director, Technology and Development Program  
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  
Acting Director, Center for Technology, Policy, and Industrial Development  
Dava J. Newman, PhD  
Professor of Aeronautics and Astronautics and Engineering Systems  
MacVicar Faculty Fellow  
Director, Technology and Policy Program  
Daniel Roos, PhD  
Japan Steel Industry Professor of Civil and Environmental Engineering and Engineering Systems  
Director, MIT Portugal Program  
Warren P. Seering, PhD  
Weber-Shaughness Professor of Mechanical Engineering and Engineering Systems  
David Simchi-Levi, PhD  
Professor of Civil and Environmental Engineering and Engineering Systems  
Codirector, LGO and SDM Programs  
John Sterman, PhD  
Jay W. Forrester Professor of Management Engineering Systems  
Director, Systems Dynamics Group  
Joseph Martin Sussman, PhD  
JR East Professor of Civil and Environmental Engineering and Engineering Systems  
James Utterback, PhD  
David J. McGrath, Jr. (1959) Professor of Management and Innovation  
Professor of Engineering Systems  
Eric von Hippel, PhD  
T. Wilson (1953) Professor of Management Engineering Systems  
David R. Wallace, PhD  
Professor of Mechanical Engineering and Engineering Systems  
MacVicar Faculty Fellow  
Codirector, MIT CADlab  
Roy Welsch, PhD  
Professor of Statistics and Management Science and Engineering Systems  
Sheila Widnall, ScD  
Professor of Aeronautics and Astronautics and Engineering Systems  
Institute Professor  
John Williams, PhD  
Professor of Civil and Environmental Engineering and Engineering Systems  
Director, Information Engineering, Auto-ID Laboratory  
Karen Witten, PhD  
Institute Professor  
Associate Professor of Mechanical Engineering and Engineering Systems  
Mary L. Cummings, Ph.D  
Associate Professor of Aeronautics and Astronautics and Engineering Systems  
Daniel D. Frey, PhD  
Associate Professor of Mechanical Engineering and Engineering Systems  
Randolph Kirchain, PhD  
Associate Professor of Materials Science and Engineering Systems  
Kenneth Oye, PhD  
Associate Professor of Political Science and Engineering Systems  
Assistant Professors  
Hamsa Balakrishnan, PhD  
T. Wilson Assistant Professor of Aeronautics and Astronautics and Engineering Systems  
Mort Webster, PhD  
Assistant Professor of Engineering Systems  
Annalisa Weigel, PhD  
Jerome C. Hunsaker Assistant Professor of Aeronautics and Astronautics and Engineering Systems  
Maria Yang, PhD  
Assistant Professor of Mechanical Engineering and Engineering Systems  
Professors of the Practice  
Christopher Magee, PhD  
Professor of the Practice of Engineering Systems and Mechanical Engineering  
Deborah Nightingale, PhD  
Professor of the Practice of Aeronautics and Astronautics and Engineering Systems  
Codirector, Lean Advancement Initiative  
Senior Lecturers  
Joseph Coughlin, PhD  
Senior Lecturer, Engineering Systems  
Director, AgeLab and New England University Transportation Center, Center for Transportation and Logistics  
Frank R. Field III, PhD  
Senior Research Associate, CTPID  
Senior Research Engineer, Materials Systems Laboratory  
Senior Lecturer, Engineering Systems  
Director, Education, Technology and Policy Program  
Patrick Hale, PhD  
Senior Lecturer, Engineering Systems  
Director, System Design and Management Fellows Program  
Donna Rhodes, PhD  
Senior Lecturer, Engineering Systems  
Principal Research Scientist, Center for Technology, Policy, and Industrial Development
Donald B. Rosenfield, PhD  
Senior Lecturer, Sloan School of Management  
Director, Leaders For Manufacturing Fellows  
Program

Daniel Whitney, PhD  
Senior Lecturer, Engineering Systems and  
Mechanical Engineering  
Senior Research Scientist, Center for Technology,  
Policy, and Industrial Development

Research Staff  
Christopher Caplice, PhD  
Senior Lecturer, Engineering Systems  
Executive Director, Center for Transportation and  
Logistics and Master of Engineering in Logistics  
Program

Stan N. Finkelstein, MD  
Senior Research Scientist, Engineering Systems  
and Health Sciences and Technology
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 science and engineering 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. In fall 2009, the new Laboratory for Advanced Materials, located across the hall, will be completed. It will contain new characterization equipment for scanning acoustic microscopy, 3-D x-ray microtomography, and 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 laboratory subject, 3.042, that emphasizes design, teamwork, and communication skills. 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 (3.7Th). 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 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, 18.03, or 18.034; 3.021J, 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 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, 2.009, 2.671, 3.042, 3.155J, 5.33, 5.36, 5.38, 6.021J/2.791J/20.370J, and 7.02.

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 concentrators with a basic knowledge of the field of archaeology, 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, 3.983, 3.987, 3.988, 3.993. The department does not seek
ABET accreditation for the 3-C program. Students may contact Professor Heather N. Lechtman 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. Because of the breadth of the undergraduate program in the department, and the variety of possibilities for specialization, the minor program is flexible in its composition. Examples of minor programs in materials science and engineering with specializations in the areas of biomaterials, ceramics, electronic materials, metallurgy, and polymers can be obtained from the department. 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 totaling 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-D), and 3.985 Archaeological Science (HASS). 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 taken outside the Course 3 program provided the coverage is equivalent. The department’s 3-C minor advisor, Professor Heather Lechtman, 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.

### 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>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement</td>
<td>6</td>
<td>8</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 [can be satisfied by 3.012 and 3.021] in the Departmental Program</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement [can be satisfied by 3.014 in the Departmental Program]</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Total GIR Subjects Required for SB Degree</strong></td>
<td><strong>17</strong></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 Units That Also Satisfy the GIRs

Subject names below are followed by credit units, and by prerequisites if any (corequisites in italics).

**Required Subjects**

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.012 Fundamentals of Materials Science and Engineering, 15, REST; 28.03*</td>
<td>128–138</td>
</tr>
<tr>
<td>3.014 Materials Laboratory, 12, LAB, CI-M</td>
<td></td>
</tr>
<tr>
<td><strong>One of the following three subjects:</strong></td>
<td></td>
</tr>
<tr>
<td>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>18.035 Differential Equations, 12, REST; Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td><strong>One of the following four subjects:</strong></td>
<td></td>
</tr>
<tr>
<td>3.021 Introduction to Modeling and Simulation, 12, REST; 28.03*</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>3.016 Mathematical Methods for Materials Scientists and Engineers, 12; Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td>3.022 Microstructural Evolution in Materials, 12; 3.012</td>
<td></td>
</tr>
<tr>
<td>3.04 Electronic, Optical, and Magnetic Properties of Materials, 12; 3.012</td>
<td></td>
</tr>
<tr>
<td>3.032 Mechanical Behavior of Materials, 12; Physics I (GIR), 3.016*</td>
<td></td>
</tr>
<tr>
<td>3.034 Organic and Biomaterials Chemistry, 12; 3.012</td>
<td></td>
</tr>
<tr>
<td>3.042 Materials Project Laboratory, 12, CI-M; 3.014*</td>
<td></td>
</tr>
<tr>
<td>3.044 Materials Processing, 12; 3.012, 3.022</td>
<td></td>
</tr>
<tr>
<td>3.051J Thesis, 9 (10) or 3.930 Industrial Practice, 6 plus 3.931 Industrial Practice, 6</td>
<td></td>
</tr>
</tbody>
</table>

**Restricted Electives**

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.016 Mathematical Methods for Materials Scientists and Engineers, 12; Calculus II (GIR)</td>
<td>48</td>
</tr>
<tr>
<td>3.021 Introduction to Modeling and Simulation, 12, REST; 28.03*</td>
<td></td>
</tr>
<tr>
<td>3.046 Thermodynamics of Materials, 12; REST; 18.03*</td>
<td></td>
</tr>
<tr>
<td>3.048 Advanced Materials Processing, 12; 3.022, 3.004</td>
<td></td>
</tr>
<tr>
<td>3.051 Materials for Biomedical Applications, 12; Chemistry (GIR), Biology (GIR), 3.012*, 5.60*</td>
<td></td>
</tr>
<tr>
<td>3.052 Nanomechanics of Materials and Biomaterials, 12; 3.032*</td>
<td></td>
</tr>
<tr>
<td>3.053 Molecular, Cellular, and Tissue Biomechanics, 12; 18.03*, Biology (GIR), 2.370*</td>
<td></td>
</tr>
<tr>
<td>3.063 Polymer Physics, 12; 3.012</td>
<td></td>
</tr>
<tr>
<td>3.064 Polymer Engineering, 12; 3.032, 3.044</td>
<td></td>
</tr>
<tr>
<td>3.07 Introduction to Ceramics, 12; 3.012</td>
<td></td>
</tr>
<tr>
<td>3.072 Symmetry, Structure, and Tensor Properties of Materials, 12; 3.016*</td>
<td></td>
</tr>
<tr>
<td>3.073 Diffraction and Structure, 12; 18.03, 3.024</td>
<td></td>
</tr>
<tr>
<td>3.074 Imaging of Materials, 12; 3.024*</td>
<td></td>
</tr>
<tr>
<td>3.080 Economic and Environmental Materials Selection, 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>3.15 Electrical, Optical, and Magnetic Materials and Devices, 12; 3.024</td>
<td></td>
</tr>
<tr>
<td>3.153 Nano/Material Processing Technology, 12, CI-M; permission of instructor</td>
<td></td>
</tr>
</tbody>
</table>

**Unrestricted Electives**

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>48</td>
</tr>
</tbody>
</table>

---

A general description of the minor program at MIT may be found under Undergraduate Education in Part 1.
Graduate Study

The Department of Materials Science and Engineering offers the degrees of Doctor of Philosophy and Doctor of Science in Materials Science and Engineering. It offers the degrees of Master of Science and Engineering, and Master of Engineering.

Doctoral Degree

The doctoral degree fields are described briefly below. Subject descriptions appropriate to the degree requirements in each of these fields are provided in the online MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi. 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.

The department’s doctoral programs are organized into four main academic fields: electronic, photonic, and magnetic materials; bio- and polymer materials; structural and environmental materials; and emerging, fundamental, and computational studies in materials science. The academic fields are not rigidly defined. Each member of the departmental faculty works in at least two of these fields and a number of subjects appear in common on the lists of elective subjects in each academic field; there is a great deal of interaction between the fields. The graduate fields are also coupled with other activities on materials within the Institute. Faculty from other departments participate in the departmental teaching and research in these fields. Subjects offered by other departments are, wherever appropriate, included in the recommended electives, and many departmental students participate in multidisciplinary research projects with students and faculty from various parts of the Institute.

Students are expected to learn the fundamentals of their chosen field and to develop a deep understanding of one or more of its significant aspects. Students are required to take further subjects designated by their academic program. A full range of advanced-level subjects is offered in each graduate field, and arrangements can be made for individually planned study of any topic. The oral examinations in the academic programs for the doctoral degree are designed accordingly. In addition, students are required to take a two- or three-subject minor program and two additional thesis-related subjects as approved by a student’s thesis committee.

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 an important 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 are also members of 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.

Electronic, Photonic, and Magnetic Materials

This program includes the science and technology of materials for electrical, magnetic, and optical device applications. It is concerned with the design and fabrication of useful materials and devices through understanding and control of the interplay between electronic, magnetic and optical properties, the micro- and nanostructure of materials (atomic arrangements, defects, interfaces, phase constitution, and morphology), and processing methods. Research within this field includes materials processing in bulk and thin-film form; device fabrication; characterization of the semiconducting, dielectric, optical, and magnetic properties of materials and devices; and theoretical study of the characteristics of bulk materials, thin-film materials and interfaces and their implications for devices.

Bio- and Polymeric Materials

This program concentrates on the science and technology of synthetic and natural materials characterized by carbon-bonded, long chain molecules of seemingly limitless architectural diversity, and their composites with inorganic materials. Polymer and nanocomposite processing by molecular-level assembly, self-assembly, and field-directed approaches are employed to create new materials displaying a wide range of structure and properties. Materials science and engineering principles are applied to the development of new products and therapies including photonic devices, battery electrolytes, organic LEDs, filtration membranes, highly recyclable plastics, resorbable implants, biosensors, and drug delivery devices.
Structural and Environmental Materials

The program on structural and environmental materials encompasses the study of the mechanical response of materials to internal and external stimuli, as well as the design and use of materials to minimize environmental impact. Research topics in the area of structural materials include microelectromechanical systems (MEMS), nanomechanics, functionally graded materials, superalloys, ceramic turbine blades, polymers, biomimicking of natural structural materials, and mechanics of cellular materials. Topics in environmental materials include materials processing to minimize environmental impact, recycling of materials, materials for energy conversion and storage (e.g., advanced battery systems, fuel cells, solar photovoltaics, smart windows, hydrides), and sensors and actuators for environmental monitoring and control.

Emerging, Fundamental, and Computational Studies in Materials Science

This program encompasses the study of fundamental and emerging concepts and technologies in materials science and engineering. The common principles that underlie the structure and properties of materials are those associated with electronic structure and bonding, atomic arrangement, phase stability, and the role of imperfections and microstructure. Fundamental phenomena considered include structural and phase transformations, reactivity, mass and charge transport, and the optical, electronic and mechanical response to internal and external stimuli. Tools of study include theory, computer modeling, and experimental characterization methods such as TEM and diffraction. This program also stimulates the integration of important developments from other fields such as mathematics, biology, physics, and economics into materials science and engineering, and allows students to propose relevant interdisciplinary course programs that may lead to emerging disciplines in materials science and engineering.

Bachelor of Science in Archaeology and Materials as Recommended by the Department of Materials Science and Engineering/Course 3-C

<table>
<thead>
<tr>
<th>General Institute Requirements (GIrs)</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>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).

Required Subjects

- 3.012 Fundamentals of Materials Science and Engineering, 15, REST; 18.03*
- 3.014 Materials Laboratory, 12, LAB, CI-M

One of the following three subjects:

- 3.016 Mathematical Methods for Materials Scientists and Engineers, 12; Calculus II (GIR)
- 18.03 Differential Equations, 12, REST; Calculus II (GIR)
- 18.034 Differential Equations, 12, REST; Calculus II (GIR)

One of the following three subjects:

- 3.022 Introduction to Modeling and Simulation, 12, REST; 18.03*
- 1.00 Introduction to Computers and Engineering Problem Solving, 12, REST; Calculus I (GIR)
- 6.01 Introduction to EECS I, 12, 1/2 LAB; Physics II (GIR)

- 3.022 Microstructural Evolution in Materials, 12; 3.012
- 3.032 Mechanical Behavior of Materials, 12; Physics I (GIR), 3.016*

or

- 3.044 Materials Processing, 12; 3.012, 3.022
- 3.1ThU Thesis, 9
- 3.095 Archaeological Science, 9, HASS; Chemistry (GIR)*
- 3.095 The Human Past: Introduction to Archaeology, 12, HASS-D
- 3.097 Human Origins and Evolution, 9, HASS
- 3.099 Seminar in Archaeological Method and Theory, 9, CI-M; 3.986, 3.985J, 21A.100
- 3.100 Introduction to Geology, 12, REST
- 12.100 Sedimentary Geology, 12; 12.001

or

- 12.119 Analytical Techniques for Studying Environmental and Geologic Samples, 12, LAB
- 21A.100 Introduction to Anthropology, 12, HASS-D

Restricted Electives

21–24 units

One subject from the following list:

- 3.07 Introduction to Ceramics, 12; 3.012
- 3.14 Physical Metallurgy, 12; 3.015, 3.022, 3.032
- 3.051 Materials for Biomedical Applications, 12; Chemistry (GIR), Biology (GIR), 3.012*, 5.60*
- 3.052 Nanomechanics of Materials and Biomaterials, 12; 3.032*

One subject from the following list:

- 3.082 The Ancient Andean World, 9, HASS
- 3.083 Ancient Mesoamerican Civilization, 9, HASS
- 3.084 Materials in Ancient Societies: Metals, 12; permission of Instructor
- 3.088 Africa—Past and Present, 9, HASS

Departmental Program Units That Also Satisfy the GIrs

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
</tr>
</tbody>
</table>

Unrestricted Electives

97 units
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, which may be taken simultaneously with other departmental or interdepartmental offerings, such as the Leaders for Global Operations program. 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 one of the Master’s Degree Registration Officers 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 3.80J, 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.

Master of Engineering Program

The department’s Master of Engineering (MEng) program covers the fundamentals of the engineering discipline and provides exposure to the tools and experience of engineering practice. This program differs significantly from the research-based SM and PhD degrees. MEng students are not eligible for research assistant support, and teaching assistant support for MEng students is rare.

The MEng program targets two categories of students: experienced professionals who are returning for “retooling” for a new career or job and experienced professionals who are sent at company expense to prepare for new or increased job responsibilities. Students are not required to have an undergraduate degree in materials science and engineering, but a strong engineering background is expected.

The program begins in the fall and has a fixed duration of 12 months. In the fall, students take two overview subjects, 3.205 and 3.225, designed for the MEng program. These subjects distill to 24 units the essential features of the 54-unit doctoral core, providing coverage of the basics of thermodynamic, kinetics, and properties of materials. These subjects offer adequate preparation for most of the department’s advanced graduate subjects but cannot substitute for the core curriculum requirements in the PhD program.

In the fall term, students take 3.206, a subject that surveys materials engineering practice, and 3.57 Materials Selection, Design, and Economics. The subject on engineering practice includes presentations by a large cross-section of the department faculty. During this first term, students and faculty also develop proposals for projects to be carried out either at a company site or on campus, in the spring (including January). Project proposals are reviewed and approved by a committee of faculty and non-faculty experts who also serve as a policy committee for the program. Projects are completed during the spring and summer terms.

In the fall or spring, students are also expected to take an advanced graduate subject from a set of restricted electives that focus on materials processing, as well as two elective graduate courses. For further information, see the MEng web page at http://dmse.mit.edu/academics/graduate/programs/meng.html.

Joint Program with the Leaders for Global Operations Program

Students planning to apply their materials science and engineering education to a career in the manufacturing industry may apply for the Leaders for Global Operations (LGO) program. 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 LGOs partner companies. The internship leads to a dual-degree thesis, culminating in two masters degreesan SM in management or an MBA, and an SM from a participating engineering department. The program is offered jointly through the MIT Sloan School of Management and the School of Engineering. For more information, see the program description under Engineering Systems Division or visit http://lgo.mit.edu/.
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 Division or visit http://tppserver.mit.edu/.

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 thermodynamics 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 or a Master of Engineering 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 chairman 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.

Faculty and Staff

Faculty and Teaching Staff
Edwin L. Thomas, PhD
Morris Cohen Professor of Materials Science and Engineering
Department Head

Professors
Samuel Miller Allen, PhD
POSCO Professor of Physical Metallurgy

Ronald George Ballinger, ScD
Professor of Materials Science and Engineering and Nuclear Science and Engineering

Angela Belcher, PhD
Germeshausen Professor of Materials Science and Engineering and Biological Engineering

W. Craig Carter, PhD
Eugene Bell Professor of Materials Science and Engineering
MacVicar Faculty Fellow

Gerbrand Ceder, PhD
Richard P. Simmons Professor of Materials Science and Engineering

Yet-Ming Chiang, ScD
Kyocera Professor of Ceramics

Michael John Cima, PhD
Sumitomo Electric Industries Professor of Engineering

Joel Phillip Clark, ScD
Professor of Materials Systems

Thomas Waddy Eagar, ScD
Professor of Materials Engineering and Materials Systems

Eugene A. Fitzgerald, PhD
Merton C. Flemings—SMA Professor of Materials Science and Engineering

Lorna Jane Gibson, PhD
Matoula S. Salapatas Professor of Materials Science and Engineering

Dorothy Hosler, PhD
Professor of Archaeology and Ancient Technology

Linn Walker Hobbs, DPhil
Professor of Materials Science and Nuclear Science and Engineering

Lionel Cooper Kimerling, PhD
Professor of Materials Systems

Sumitomo Electric Industries Professor of Chemistry and Nuclear Engineering

Thomas Lord Professor of Materials Science and Engineering

Klavs Flemming Jensen, PhD
Director, Materials Processing Center

Warren K. Lewis Professor of Chemical Engineering and Materials Science and Engineering

Heather Nan Lechtman, MA
Director, Center for Materials Research in Archaeology and Ethnology

Joel Phillip Clark, ScD
Professor of Materials Systems

Michael John Cima, PhD
Toyota Professor of Materials Science and Engineering

MacVicar Faculty Fellow
Caroline Anne Ross, PhD  
Toyotra Professor of Materials Science  
Michael Francis Rubner, PhD  
TDK Professor of Materials Science and Engineering  
Director, Center for Materials Science and Engineering  
Donald Robert Sadoway, PhD  
John F. Elliott Professor of Metallurgy  
Subra Suresh, ScD  
Vannevar Bush Professor of Engineering  
Professor of Materials Science and Engineering, Mechanical Engineering, and Biological Engineering  
Affiliated Faculty, Harvard-MIT Division of Health Sciences and Technology  
Dean of Engineering  
Carl Vernette Thompson II, PhD  
Stavros Salapatas Professor of Materials Science and Engineering  
Harry Louis Tuller, EngScD  
Professor of Ceramics and Electronic Materials  
Director, Crystal Physics and Optical Electronics Laboratory  
Bernhardt John Wuensch, PhD  
Professor of Ceramics  
Sidney Yip, PhD  
Professor of Nuclear Science and Engineering  
and Materials Science and Engineering  
Christopher Schuh  
Danae and Vasilis Salapatas Associate Professor of Metallurgy  
Francesco Stellacci, PhD  
Fimmeccanica Career Development Associate Professor of Materials Science and Engineering  
Yang Shao-Horn, PhD  
Associate Professor of Mechanical Engineering  
and Materials Science and Engineering  
Assistant Professors  
Alfredo Alexander-Katz, PhD  
Assistant Professor of Materials Science and Engineering  
Geoffrey Stephen Beach, PhD  
Assistant Professor of Materials Science and Engineering  
Michael J. Demkowicz, PhD  
Assistant Professor of Materials Science and Engineering  
Silvija Gradecak, PhD  
Merton C. Flemings Career Development Assistant Professor of Materials Science and Engineering  
Randolph E. Kirchain, Jr., PhD  
Assistant Professor of Materials Science and Engineering  
Krystyn Van Vliet, PhD  
Thomas Lord Assistant Professor of Materials Science and Engineering  
Senior Lecturers  
Paul I. David, PhD  
James Duane Livingston, PhD  
Lecturers  
Geetha Berera, PhD  
Joseph M. Dhosi  
Arne Hessenbruch, PhD  
Harry Vincent Merrick, PhD  
Joseph Parse, PhD  
Meri Treska, PhD  
Technical Instructors  
Sidney W. Carter  
Michael J. Tarkanian  
Yin-Lin Xie  
Instructor  
Peter Houk  
Research Staff  
Visiting Scientists  
Shen Dillon  
Marco Fornari  
Samed Halilov  
Yuichiro Koizumi  
Boris Kozinsky  
Thomas A. Langdo  
Vivian Ng  
David Rodney  
Luanne Rolly  
Prabhat K. Tripathy  
Yu Watanabe  
Conrad Kang Xu  
Haipeng Zheng  
Senior Research Associate  
Robert Charles O’Handley  
Research Associate  
Xiaoman Duan  
Research Scientists  
David Bono  
Sidney W. Carter  
Ming Dao  
Martin Maldovan  
Luis A. Ortiz  
Jifa Qi  
Alan Schwartzman  
Sponsored Research Technical Staff  
Donald Galler  
Research Specialist  
George LaBonte  
Technical Assistants  
Vesel Dini  
Amy M. Winans  
Postdoctoral Associates  
Nicola Bonini  
Fevzi C. Cebeci  
Dandeniyage C. I. De Alwis  
Robert E. Doe  
Mirela A. Dragan  
Cedric Dubois  
Can K. Erdonmez  
Georg Ernest Fantner  
Christopher Carl Fischer  
Debadyuti Ghosh
Byung Chan Han
Celine Nathalie Hin
Ying Hu
Ji Hyun Jang
Mohammad Mukul Kabir
Hyun Suk Kim
Woo Soo Kim
Pinar Kurt
Jae-Hwang Lee
Wentao Li
Martin Maldovan
Timothy K. Mueller
Sahak Petrosyan
Ratchatee Techapiresancharoenkij
Jonathan C. Trenkle
Soong Ho Um
Oktay Uzun
Ayush Verma
Yang Wang
Qingfeng Yan
Gang Yang
Haimin Yao
Fei Zhou
Jessada Wannasin
John Zhenyu Wen
Arum Yu

Professors Emeriti
Robert Weierter Balluffi, ScD
Professor of Physical Metallurgy, Emeritus

Merton C. Flemings, ScD
Toyota Professor of Materials Processing, Emeritus

Harry Constantine Gatos, PhD
Professor of Molecular Engineering and Electronic Materials, Emeritus

Ronald Michael Latanision, PhD
Professor of Materials Science and Engineering

Frederick Jerome McGarry, SM
Professor of Civil Engineering and Polymer Engineering, Emeritus

Regis Marc Noel Pelloux, ScD
Professor of Materials Engineering, Emeritus

Robert Michael Rose, ScD
Professor of Materials Science and Engineering, Emeritus
Director, Concourse Program

Kenneth Calvin Russell, PhD
Professor of Metallurgy and Nuclear Engineering, Emeritus

John Bruce Vander Sande, PhD
Professor of Material Science, Emeritus

Postdoctoral Fellows
Monica A. Diez Silva
Donghyun Kim
Hyun Suk Kim
Young Gun Ko
Denis Kramer
Georgios Lykotrafitis
Chung Hee Nam
Marc D. Natter
David Naves Otero
Hong Zhang

Research Affiliates
Fernando Castano
Connie Cheng
Gerald F. Dionne
Richard J. Gyory
Hsiao-Ying Huang
Young-II Jang
Theodoulos Kattamis
Davide M. Marini
Douglas Matson
Richard Mlcak
George A. Rossetti
Chris Scott
Hao Wang
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 impassion 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 engineer-
ing; 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 manufacture-
ting 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 2-0E 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 un-
derstanding for the development of novel ocean
systems studying marine animals; the study of
the mechanics and fluid mechanics of systems
for ultradepth 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, includ-
ing 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 multidisci-
plinary 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

Bachelor of Science in Mechanical Engineering/Course 2

<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 [can be satisfied by 2.001 and 18.03 in the Departmental Program]</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement [can be satisfied by 2.671 in the Departmental Program]</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>

<table>
<thead>
<tr>
<th>Communication Requirement</th>
</tr>
</thead>
<tbody>
<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) [satisfied by 2.009 and 2.671 in the Departmental Program].</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PLUS Departmental Program</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Departmental Core Subjects</td>
<td>159</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 II (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 Thermal-Fluids Engineering II, 12; 2.004, 18.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.008 Design and Manufacturing II, 12, 1/2 LAB; 2.001, 2.005, 2.017, 2.027</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.009 The Product Engineering Process, 12, CI-M; 2.001, 2.003, 2.005, 2.670, 2.671; senior standing or permission of instructor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.086 Numerical Computation for Mechanical Engineers, 12; 2.001, 2.003J, 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>2.672 Project Laboratory, 6, 1/2 LAB; 2.001, 2.003J, 2.006, 2.671</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>2.71U Undergraduate Thesis, 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and either</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>or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.017 Design of Electromechanical Robotic Systems, 12, 1/2 LAB; 2.003J, 2.005 or 2.016, 2.671</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restricted Elective Subjects</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 ME Undergraduate Office]:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.016 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; 2.003J, 2.005 or 2.016, 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 or 2.016; senior standing or permission of instructor</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>2.12 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>2.370 Molecular Mechanics, 12; 2.001, Chemistry (GIR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.41 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>2.71 Optics, 12; Physics II (GIR), 18.03; 2.004*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.72 Elements of Mechanical Design, 12; 2.005, 2.007, 2.671</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.793 Fluids, Forces and Flows in Biological Systems, 12; 2.005, 6.021, 20.320, or permission of instructor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.797 Molecular, Cellular, and Tissue Biomechanics, 12; 18.03 or 3.016; Biology (GIR), 2.370 or 2.772</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.813 Environmentally Benign Design and Manufacturing, 12; 2.008 or permission of instructor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.96 Management in Engineering, 12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Departmental Program Units That Also Satisfy the GIRs | (36) |
| Unrestricted Elective(s) | 48 |

| Total Units Beyond the GIRs Required for SB Degree | 195 |

*No subject can be counted both as part of the 17-subject GIRs and as part of the 195 units required beyond the GIRs. Every subject in the student’s departmental program will count toward one or the other, but not both.
understand biological processes and to harness them successfully for human use. Mechanical forces and structures play an essential role in 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 systems, 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 nano- and microfabrication 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 nanoengineering 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 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.
Bachelor of Science in Engineering as recommended by the Department of Mechanical Engineering/Course 2-A

General Institute Requirements (GIRs)

Science Requirement
Humanities, Arts, and Social Sciences Requirement
Restricted Electives in Science and Technology (REST) Requirement (can be satisfied by 2.001 and 18.03 in the Departmental Program)
Laboratory Requirement (satisfied by 2.671 in the Departmental Program)

Total GIR Subjects Required for SB Degree

Communication Requirement
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) (satisfied by 2.009 and 2.671 in the Departmental Program).

PLUS Departmental Program

Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

Required Departmental Core Subjects

2.003 Mechanics and Materials I, 12, REST; Physics I (GIR), Calculus II (GIR), 18.03
2.005 Dynamics and Control I, 12, REST; Physics I (GIR), 18.03
2.006 Thermal-Fluids Engineering I, 12, REST; Physics II (GIR), Calculus II (GIR), 18.02
2.009 The Product Engineering Process, 12, CI-M; 2.001, 2.003J, 2.005; 2.670 or 2.00B; senior standing or permission of instructor
2.671 Measurement and Instrumentation, 12, LAB, CI-M; 2.001, 2.003J, Physics II (GIR)
18.03 Differential Equations, 12, REST; Calculus II (GIR)

Two Additional Mechanical Engineering Subjects

2.002 Mechanics and Materials II, 12; 2.003, Chemistry (GIR)
2.004 Dynamics and Control II, 12; 2.003J, Physics II (GIR)
2.006 Thermal-Fluids Engineering II, 12; 2.005, 18.03
2.007 Design and Manufacturing I, 12; 2.001
2.008 Design and Manufacturing II, 12, 1/2 LAB; 2.001; 2.005; 2.007 or 2.017
2.086 Numerical Computation for Mechanical Engineers, 12; 2.001, 2.003J, 2.005
2.017J Undergraduate Thesis, 12

Elective Subjects with Engineering Content

72

Departmental Program Units That Also Satisfy the GIRs

(36)

Unrestricted Electives

48

Total Units Beyond the GIRs Required for SB Degree

183

Notes

* Alternate prerequisites and corequisites are listed in the subject description.

(1) These electives define a concentrated area of study and must be chosen with the written approval of the ME Undergraduate Office. A minimum of 69 units of engineering topics must be included in the 72 units of concentration electives. 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. A thesis (2.017J) of up to 12 units may be included among the concentration subjects if not already applied to the second-level 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.
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 biomedical engineering and pre-medicine; energy conversion engineering; engineering management; product development; robotics; sustainable development; architecture and building technology; and any of the seven departmental focus areas mentioned above. The ME faculty have developed specific recommendations in some of these areas; details are available from the ME 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 66 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.

To pursue the 2-A degree, students must submit the 2-A enrollment form to the ME Undergraduate Office, Room 1-110, no later than Add Date of their second term in the program. Enrollment forms are available in that office.

### 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></td>
<td>6</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 [can be satisfied by 2.001 and 18.03 in the Departmental Program]</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement [can be satisfied by 2.671 in the Departmental Program]</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) [satisfying 2.019 and 2.671 in the Departmental Program].

### PLUS Departmental Program

**Required Departmental Subjects**

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>147</td>
</tr>
</tbody>
</table>

- 2.001 Mechanics and Materials I, 12, REST; Physics I (GIR), Calculus II (GIR), 18.03
- 2.003 Dynamics and Control I, 12, REST; Physics I (GIR), 18.03
- 2.004 Dynamics and Control II, 12; 2.003J, Physics II (GIR)
- 2.005 Thermal-Fluids Engineering, 12, REST, Physics II (GIR), Calculus II (GIR), 18.03
- 2.012 Mechanics of Structures, 12, 2.001 or 1.050
- 2.016 Hydrodynamics, 12; Physics II (GIR), 18.03
- 2.017 Design of Electromechanical Robotic Systems, 12; 1/2 LAB; 2.003J; 2.016 or 2.005; 2.671
- 2.019 Design of Ocean Systems, 12, CI-M; 2.001; 2.003J; 2.005 or 2.016; senior standing or permission of instructor
- 2.086 Numerical Computation for Mechanical Engineers, 12; 2.001, 2.003J, 2.005
- 2.612 Marine Power and Propulsion, 12; 2.005
- 2.670 Mechanical Engineering Tools, 3
- 2.671 Measurement and Instrumentation, 12, LAB, CI-M; 2.001, 2.003J, Physics II (GIR)
- 18.03 Differential Equations, 12, REST; Calculus II (GIR)

### Restricted Elective Subjects

- Students are required to take two of the following electives subjects (substitutions by petition to the ME Undergraduate Office):
  - 2.006 Thermal Fluids Engineering II, 12; 2.005, 18.03
  - 2.007 Design and Manufacturing I, 12; 2.001
  - 2.008 Design and Manufacturing II, 12, 1/2 LAB; 2.001; 2.005; 2.007 or 2.017
  - 2.005 Acoustics and Sensing, 12; 2.003J, 6.003, 8.03, or 16.03
  - 2.092 Computer Methods in Dynamics, 12; 2.001, 2.003J
  - 2.12 Introduction to Robotics, 12; 2.004
  - 2.14 Analysis and Design of Feedback Control Systems, 12; 2.004
  - 2.51 Intermediate Heat and Mass Transfer, 12; 2.006*
  - 2.610 Fundamentals of Advanced Energy Conversion, 12; 2.006*
  - 2.701 Principles of Naval Architecture, 12; 2.002 or 2.012
  - 2.706 Sailing Vessel Design, 12; 2.701 or permission of instructor
  - 2.79 Elements of Mechanical Design, 12; 2.005, 2.007, 2.671
  - 2.96 Management in Engineering, 12

**Departmental Program Units That Also Satisfy the GIRs**

- Restricted Electives

- Unrestricted Electives

- Total Units Beyond the GIRs Required for SB Degree

---

**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.
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 courses, 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 Luperfroy, executive director, Room 12-193, 617-253-0055, upop@mit.edu, or from http://web.mit.edu/engineering/upop/.

Minor in Mechanical Engineering
The requirements for a Minor in Mechanical Engineering are as follows:
Students pursuing a minor in the department must complete a total of six subjects (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 ME program’s required core subjects.

Inquiries
Further information on undergraduate programs may be obtained from the 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 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 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. 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. Those with deficiencies may be asked to make up subjects in certain areas before they graduate.

Applications for September entry are due on December 15 of the previous year (except for the Master of Engineering, which has a January 15 deadline), and decisions are reported in March. Foreign 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. Students applying from non-English-speaking countries are required to take the International English Language Testing System (IELTS) exam (now the preferred testing method for the Department of Mechanical Engineering) and receive a minimum score of 7, or the Test of English as a Foreign Language (TOEFL) exam (to be phased out by 2020) with a minimum paper-based score of 577, or a minimum computer-based score of 233, or a minimum internet-based score of 91.
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 foreign, must take the departmental writing ability test, which is administered in September. Depending on the results, a student will either pass or be required to take a subject in writing.

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 ME 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 ME website). Students must take at least one graduate mathematics subject (12 units) offered by the MIT Mathematics Department. No waivers are allowed.

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
The curriculum leading to a Master of Science in Ocean Engineering is based on a broad working knowledge of all the basic engineering skills. The intended outcome of this program is to prepare a person whose main interest is the development of the resources of the ocean for the good of humanity, and who, in following this ambition, is prepared to use whatever engineering disciplines are needed to address the problem at hand.

As a part of the more general field of ocean engineering, naval architecture and marine engineering are concerned with all aspects of waterborne vehicles operating on, below, or just above the sea surface. The Master of Science in Naval Architecture and Marine Engineering is intended to develop an individual who plans to concentrate in areas related to waterborne vehicles and/or their subsystems.

The requirements for these degrees are that the student take 72 credit units of subjects— with 48 of them being H-level subjects—and complete a thesis. At least three of the subjects must be chosen from a prescribed list of basic ocean engineering subjects (refer to the Guide to Graduate Study on the ME website). Students must take at least one graduate mathematics subject (12 units) offered by MIT’s Mathematics Department. No waivers are allowed.

Master of Engineering in Manufacturing
The Master of Engineering in Manufacturing is a twelve-month professional degree in mechanical engineering that is intended to prepare the student to assume a role of technical leadership in the manufacturing industries. The degree is aimed at practitioners who will use this knowledge to become leaders in existing, as well emerging, manufacturing companies. To qualify for this degree, a student must complete a highly integrated set of subjects and projects that cover the process, product, system, and business aspects of manufacturing, totaling 90 units, plus complete a group-based thesis project with a manufacturing industry. While centered in engineering and firmly grounded in the engineering sciences, this degree program considers the entire enterprise of manufacturing. Students will gain both a broad understanding of the many facets of manufacturing and a knowledge of manufacturing fundamentals from which to build new technologies and businesses. The admission process is identical to that of the Master of Science degree, with the exception that a supplemental application is required. For more information, see the program description at http://web.mit.edu/~meng-manufacturing/.

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 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 SM in management or an MBA, and an SM from a participating engineering department. The program is offered jointly through the MIT Sloan School of Management and the School of Engineering. For more information, see the program description under Engineering Systems Division or visit http://lgo.mit.edu/.

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

C O U R S E  2
M E C H A N I C A L  E N G I N E E R I N G
advanced engineering problems and includes 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 program leading to the Naval Engineer’s degree requires a higher level and significantly broader range of professional competence in engineering than is required for an SM in naval architecture and marine engineering or ocean engineering. The program for an engineer’s degree ordinarily includes subjects in the areas of economics, industrial management, and public policy or law, and at least 12 units of comprehensive design. Should the student be working toward the simultaneous award of the engineer’s and master’s degrees, a single thesis is generally acceptable provided it is appropriate to the specifications of both degrees and demonstrates the educational maturity expected of candidates for the higher degree.

The Naval Construction and Engineering (NCE) 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 engineering education for a career as a professional naval engineer. The program focuses on naval architecture, hydrodynamics, ship structures, materials, power and propulsion, and ship production in a total-ship-design and engineering context. Students learn to apply a total-system-design approach to large-scale complex systems—in particular, surface naval combatants, submarines, and high-performance commercial ships. The program is appropriate for naval officers and civilians who later actively participate in concept formulation, design, and construction of naval ships, as well as for those interested in commercial ship design. In addition to general engineering and science and a core program of subjects in ocean engineering, each student follows one of several specialized curricula applicable to ship construction and engineering.

**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 doctorate by passing the doctoral qualifying examinations. The doctoral program includes a major program of advanced study and a doctoral committee in the student’s principal area of interest, and a minor program of study in a different field. The 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 Departmental 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.

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 Mechanical Engineering 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 interdisciplinary or school-wide research activities. These include the Biotechnology Process Engineering Center, Center for Biomedical 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 Energy and the Environment, Laboratory for Manufacturing and Productivity, Operations Research Center, Program in Polymer Science and Technology, and Sea Grant College Program. Detailed information about each 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 micro-fluidic 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
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 21st-Century Energy
Innovative science and technology for a sustainable energy future. Fundamental research in transport phenomena and thermodynamics; applied research in energy conversion, transportation, and thermal management. Drawn upon activities in several of the department’s laboratories.

Cryogenic Engineering Laboratory
Application of thermodynamics, heat transfer, and mechanical design to cryogenic processes and apparatus and the operation of a liquid helium facility.

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.

Rohsenow Heat and Mass Transfer Laboratory
Fundamental research in convection, microscale/nanoscale transport, laser/material interaction, and high heat fluxes; applied research in water purification, thermoelectric devices, energy-efficient buildings, and thermal management of electronics.

Sloan Automotive Laboratory
Processes and technology that control the performance, efficiency, and environmental impact of internal combustion engines, their lubrication, and fuel requirements.

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:

- Acoustics Group: Research in ocean acoustics, acoustic sensing for naval applications, fisheries, ocean exploration and mapping, ocean observation systems, signal processing, and detection in the underwater environment.
- Design Laboratory: Research in biomimetics, robotics, naval architecture, ship and offshore structure design, computer-aided design and manufacturing, geometric modeling and computer visualization, distributed systems for ocean forecasting, adaptive ocean sampling methodologies, cable and riser dynamics and design, and marine transportation. Affiliated with the MIT Sea Grant Autonomous Underwater Vehicles Lab.
- Hydrodynamics Group: Includes the Marine Hydrodynamics Laboratory (Propeller Tunnel) and the Testing Tank Facility (Towing Tank); the Vortical Flow Research Laboratory; the Laboratory for Ship and Platform Flows; and the Marine Computation and Instrumentation Laboratory. Research areas include experimental fluid mechanics, vortex-induced hydrodynamic loads, seaweeding, maneuvering and control, computational fluid dynamics, hydrodynamic load prediction, performance evaluation of ocean vehicles, wave-field analysis and prediction, propulsor system design, marine robotics, biomimetics, air-sea interaction, and advanced sailing-boat design.
- Structural Mechanics and Dynamics Group: Includes the Impact and Crashworthiness Laboratory, with emphasis on structural mechanics of large complex structures, impact loads and weapon effects on structures, and crashworthiness.
- Structural Dynamics Laboratory: Emphasis on vortex-induced vibrations and riser dynamics.
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.

---

**FACULTY AND STAFF**

**Faculty and Teaching Staff**
Mary C. Boyce, PhD
Gail E. Kendall Professor of Mechanical Engineering
MacVicar Faculty Fellow
Department Head

Gareth H. McKinley, PhD
School of Engineering Professor of Teaching Innovation
Professor of Mechanical Engineering
Class of 1960 Fellow
Associate Department Head

Michael S. Triantafyllou, ScD
W. I. Koch Professor of Marine Technology
Professor of Mechanical and Ocean Engineering
Associate Department Head

John H. Lienhard V, PhD
Samuel C. Collins Professor of Mechanical Engineering
Director, KFUPM Center for Clean Water and Clean Energy
Executive Officer

**Professors**
Rohan Abeyaratne, PhD
Quentin Berg Professor of Mechanics
MacVicar Faculty Fellow

Triantaphyllos R. Akylas, PhD
Professor of Mechanical Engineering

Lallit Anand, PhD
Professor of Mechanical Engineering

H. Harry Asada, PhD
Ford Professor of Engineering
Director, d’Arbeloff Laboratory for Information Systems and Technology

Arthur B. Bagheroer, ScD
Ford Professor of Engineering
Professor of Mechanical, Ocean, and Electrical Engineering

Klaus-Jürgen Bathe, PhD, DSc, Dr-Ing Eh, Dr hc Mult
Professor of Mechanical Engineering

John G. Brisson II, PhD
Professor of Mechanical Engineering

Gang Chen, PhD
Warren and Townley Rohsenow Professor of Mechanical Engineering

Wai K. Cheng, PhD
Professor of Mechanical Engineering

Chryssostomos Chryssostomidis, PhD
Professor of Mechanical and Ocean Engineering
Director, MIT Sea Grant College Program

Jung-Hoon Chun, PhD
Professor of Mechanical Engineering
Director, Laboratory for Manufacturing and Productivity

Ernest G. Cravalho, PhD
Professor of Mechanical Engineering
MacVicar Faculty Fellow

C. Forbes Dewey, Jr., PhD
Professor of Mechanical and Biological Engineering

Steven Dubowsky, ScD
Professor of Mechanical Engineering and Aeronautics and Astronautics

Ahmed F. Ghoniem, PhD
Ronald C. Crane Professor of Mechanical Engineering
Codirector, Center for 21st Century Energy

Lorna J. Gibson, PhD
Matoula S. Salapatas Professor of Materials Science and Engineering
Professor of Mechanical Engineering and Civil and Environmental Engineering

Leon R. Glicksman, PhD
Professor of Mechanical Engineering and Architecture

David C. Gossard, PhD
Professor of Mechanical Engineering

Stephen C. Graves, PhD
Abraham Siegel Professor of Management
Professor of Mechanical Engineering and Management

Linda G. Griffith, PhD
School of Engineering Professor of Teaching Innovation
Professor of Mechanical and Biological Engineering
Director, Biotechnology Process Engineering Center
Daniel Frey, PhD  
Associate Professor of Mechanical Engineering  
and Engineering Systems  
(On leave, fall)

Trent Gooding, NE  
Associate Professor of the Practice of Naval  
Construction and Engineering

Nicolas G. Hadjiconstantinou, PhD  
Associate Professor of Mechanical Engineering  
(On leave)

Anette E. Hosoi, PhD  
Associate Professor of Mechanical Engineering  
(On leave, spring)

Joseph Jacobson, PhD  
Associate Professor of Mechanical Engineering  
and Media Arts and Sciences

Sang-Gook Kim, PhD  
Associate Professor of Mechanical Engineering

Matthew J. Lang, PhD  
Associate Professor of Mechanical and Biological  
Engineering

Pierre F. J. Lermusiaux, PhD  
Doherty Associate Professor of Ocean Utilization

Carol Livermore, PhD  
Associate Professor of Mechanical Engineering

Scott Manalis, PhD  
Associate Professor of Mechanical and Biological  
Engineering  
Associate Member, Broad Institute

Thomas Peacock, PhD  
Associate Professor of Mechanical Engineering

Sanjay E. Sarma, PhD  
Associate Professor of Mechanical Engineering  
MacVicar Faculty Fellow

Yang Shao-Horn, PhD  
Associate Professor of Mechanical Engineering  
and Materials Science and Engineering  
(On leave, fall)

Alexandra H. Techet, PhD  
Associate Professor of Mechanical and Ocean  
Engineering

**Assistant Professors**

- Cullen Buie, PhD  
  Assistant Professor of Mechanical Engineering
- Tonio Buonassisi, PhD  
  SMA Assistant Professor of Mechanical  
  Engineering and Manufacturing
- Kimberly Hamad-Schifferli, PhD  
  Assistant Professor of Mechanical and Biological  
  Engineering
- Franz Hover, PhD  
  Doherty Assistant Professor in Ocean Utilization
- Rohit N. Karnik, PhD  
  d'Arbeloff Assistant Professor of Mechanical  
  Engineering
- Sangbae Kim, PhD  
  Assistant Professor of Mechanical Engineering
- Alexander Mitsos, PhD  
  Assistant Professor of Mechanical Engineering
- Kripa Varanasi, PhD  
  d’Arbeloff Assistant Professor of Mechanical  
  Engineering
- Evelyn N. Wang, PhD  
  Esther and Harold E. Edgerton Assistant  
  Professor of Mechanical Engineering
- Maria C. Yang, PhD  
  Robert N. Noyce Assistant Professor of  
  Mechanical Engineering and Engineering  
  Systems  
  (On leave, spring)

**Senior Lecturers**

- John P. Appleton, PhD  
  Arthur Bergles, PhD  
  Ernesto E. Blanco, BME  
  David V. Burke, PhD  
  Stephen D. Fantone, PhD  
  Dean Kamen, PhD  
  Raymond, McCord, PhD  
  William Plummer, PhD  
  Mark Schattenburg, PhD  
  Amy Smith, SM  
  Myron Spector, MD  
  Barrick Tibbitts, NE  
  Daniel E. Whitney, PhD

**Lecturers**

- Alex Arzoumanidis, PhD  
  Harrison Chin, PhD  
  Richard Fenner, BS  
  Julio Guerrero, PhD  
  Barbara Hughey, PhD  
  Richard Kimball, PhD  
  Philip Koenig, ScD  
  Richard Lee, MD  
  Guoan Li, PhD  
  Sheng Liu, PhD  
  James Preisig, PhD  
  Victor Wong, PhD  
  Robert Wunderlick, MA  
  Boo-Hoo Yang, PhD  
  Dana R. Yoerger, PhD

**Instructors**

- Harrison Chin, PhD  
- Barbara Hughey, PhD

**Technical Instructors**

- Joseph Cronin  
- David Dow  
- Pierce Hayward  
- Patrick McAtamney

**Research Staff**

**Senior Research Engineers/  
Scientists**

- Anuradha Annaswamy, PhD  
- Stanley B. Gershwin, PhD  
- Mandayam A. Srinivasan, PhD

**Principal Research Engineers/  
Scientists**

- James Brede, PhD  
- Karl Iagnemma, PhD  
- Lynette A. Jones, PhD  
- H. Igo Krebs, PhD  
- Yuming Liu, PhD

**Research Engineers/Scientists**

- Arjuna Balasuriya, PhD  
- Wonjoon Cho, PhD  
- Laura Dipietro, PhD  
- John Folkesson, PhD  
- Patrick Haley, PhD  
- Kelli Hendrickson, PhD  
- Nora C. Hogan, PhD  
- Wayne Leslie, SM
Postdoctoral Associates
Sung-Jin Ahn, PhD
Bader Al-Anzi, PhD
Mohammad-Reza Alam, PhD
Panagiotis Artemiadis, PhD
Marie-Eve Aubin-Tan, PhD
Michael Benjamin, PhD
Roland Bouffanais, PhD
Remi Bourguet, PhD
Hye Ryung Byon, PhD
Shuo Chen, PhD
Mostafa El Sharqawy, PhD
Hossam El-Asrag, PhD
Maurice Fallon, PhD
Waleed Farahat, PhD
Shien-Ping Feng, PhD
Amin Ghoheity, PhD
Lei Gu, PhD
Sang Eon Han, PhD
Celine Hin, PhD
Tomonori Honda, PhD
Susumu Imashuku, PhD
Genya Ishigami, PhD
Kenneth Kar, PhD
David Knezevic, PhD
Ethan Parsons, PhD
Mohammad Rastgaar-Aagaah, PhD
Yuan Luo, PhD
Andrew McCarthy, PhD
Yahya Modarres-Sadeghi, PhD
Bhaskaran Muralidharan, PhD
Se Baek Oh, PhD
Ethan Parsons, PhD
Mohammad Rastgaar-Aagaah, PhD
Renault Rinaldi, PhD
Santosh Shanbhogue, PhD
Vivek Sharma, PhD
Yixiang Shi, PhD
Anup Shiraonkar, PhD
Niraj Sinha, PhD
Saeed Sokhanvar, PhD
Johannes Soulages, PhD
Cheng Hock Tan, PhD
Lifeng Wang, PhD
Jinshan Xu, PhD
Zhichuan Xu, PhD
Se Young Yang, PhD
Haidong Yuan, PhD
Cheng Zhang, PhD

Professors Emeriti
Ali S. Argon, ScD
Quentin Berg Professor of Mechanical Engineering, Emeritus
A. Douglas Carmichael, PhD
Professor of Mechanical and Power Engineering, Emeritus
Stephen H. Crandall, PhD
Ford Professor of Engineering, Emeritus
Ira Dyer, PhD
Professor of Mechanical and Ocean Engineering, Emeritus
James A. Fay, PhD
Professor of Mechanical Engineering, Emeritus
Woodie C. Flowers, PhD
Pappalardo Professor of Mechanical Engineering, Emeritus
Ernst G. Frankel, PhD, DBA
Professor of Mechanical Engineering and Marine Systems, Emeritus
Peter Griffith, ScD
Professor of Mechanical Engineering, Emeritus
Elia P. Gyftopoulos, ScD
Ford Professor of Engineering, Emeritus
James C. Keck, PhD
Professor of Mechanical Engineering, Emeritus
Justin E. Kerwin, PhD
Professor of Mechanical Engineering and Naval Architecture, Emeritus
Shih-Ying Lee, ScD
Professor of Mechanical Engineering, Emeritus
Richard H. Lyon, PhD, DrEng (hon)
Professor of Mechanical Engineering, Emeritus
Koichi Masubuchi, PhD
Kawasaki Professor of Engineering, Emeritus
Professor of Mechanical and Ocean Engineering and Materials Sciences and Engineering, Emeritus
T. Francis Ogilvie, PhD
Professor of Mechanical and Ocean Engineering, Emeritus
Carl R. Peterson, ScD
Professor of Mechanical Engineering, Emeritus
Ronald F. Probstein, PhD
Ford Professor of Engineering, Emeritus
Warren M. Rohsenow, DEng
Professor of Mechanical Engineering, Emeritus
Thomas B. Sheridan, ScD, D (hon)
Ford Professor of Engineering and Applied Psychology, Emeritus
Ain A. Sonin, PhD
Professor of Mechanical Engineering, Emeritus
Nam P. Suh, PhD, LHD (hon), EngD (hon), TekD (hon)
Ralph E. and Eloise F. Cross Professor of Mechanical Engineering, Emeritus
Neil E. Todreas, PhD
Professor of Nuclear and Mechanical Engineering, Emeritus
James H. Williams, Jr., PhD
School of Engineering Professor of Teaching Excellence, Emeritus
Professor of Mechanical Engineering and Writing and Humanistic Studies, Emeritus
David Gordon Wilson, PhD
Professor of Mechanical Engineering, Emeritus
Gerald L. Wilson, ScD
Vannevar Bush Professor of Electrical and Mechanical Engineering, Emeritus
The Department of Nuclear Science and Engineering provides undergraduate and graduate education for students interested in developing peaceful applications of nuclear science and engineering. This is an exciting time to study nuclear science and engineering: society’s interest in, and need for, a clean energy source such as nuclear energy is at a 20-year high. The applications of other nuclear technologies in medicine and industry have focused attention on the value of a strong nuclear science and engineering program. In response to this demand, the department has developed a discipline-focused program of study that prepares students for the many diverse applications of nuclear science and technology. Applied nuclear science is the core discipline, underlying all these applications, that includes low energy nuclear physics, the interaction of ionizing radiation with matter, and plasma science and technology.

The department’s view of nuclear science and engineering is manifest in our unified core curriculum for all our graduate students and our discipline-based undergraduate program. Once the core material is mastered, students can select from a wide variety of applications through more specialized subjects.

Applications can be sorted into three overlapping subcategories: nuclear energy, plasma physics and fusion technology, and the broad area of nuclear science and technology. In keeping with MIT’s longstanding contributions to the well-being of the nation, the department aims to educate the individuals who will make the key scientific and engineering advances in these societally important fields. Each of the three basic research areas involves substantial faculty and student activities. A synopsis of these activities follows.

**Nuclear Energy.** Nuclear reactors, using the fissioning of heavy elements such as uranium, supply approximately 17 percent of electricity worldwide and power ships and submarines. They produce radioisotopes for medical, biological, and industrial uses, and for long-lived onboard spacecraft power. They could also provide energy for chemical and industrial processing and portable fuel production (e.g., synthetic fuels or hydrogen).

The generation of electricity by nuclear power is probably the most familiar application. In some countries, the fraction of electricity obtained from nuclear power is greater than 80 percent. In the United States, it is about 20 percent. Concerns about the unreliability of fossil fuel supplies and the need for new domestic supplies of electricity have led to a resurgence of interest in the design of advanced nuclear reactors. Nuclear reactors emit no greenhouse gases and therefore represent a highly attractive and realistic option for reducing the pollution that is causing global climate change.

The safe and economical development, design, construction, and operation of nuclear power plants and their related nuclear fuel recycling facilities is a major field of engineering. Future Nuclear Science and Engineering research goals are focused on: developing new advanced nuclear reactor designs that include passive safety features; developing innovative new proliferation-resistant fuel cycles; extending the life of nuclear fuels and structures; and reducing the capital and operating costs of nuclear power stations. The goal is to make nuclear power the most economical, safe, and environmentally friendly way of generating electricity, thereby making a major contribution to our energy independence and a sustainable global climate.

The Department of Nuclear Science and Engineering is also an active participant in MIT’s interdisciplinary programs of instruction and research in the management of complex technological systems and technology and public policy. This is a growing and important area, since policy makers need more effective tools in assessing complex systems and human behavior.

**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 Science and Technology.** The department’s nuclear science and technology program is concerned with the continued development of low energy nuclear science and its application to fields such as medicine and biology, information processing, materials research, industrial processes, and radiation detection.

Biological 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.

A 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.

A cross-cutting area of research in the department involves the area of nuclear materials research. Understanding how radiation interacts with biological materials is a major interest in the nuclear science and technology program. However, materials also are critical in the nuclear power and fusion programs. Here, in order to achieve the full potential of nuclear energy from either fission or fusion reactors, it is necessary to develop special materials capable of withstanding intense radiation for long periods of time. It is also crucial to understand the phenomenon of corrosion in a radiation environment.

Nuclear science and engineering makes important contributions to a wide range of industrial applications. For example, nuclear techniques are being used and developed for the rapid, non-intrusive inspection of aircraft baggage and cargo. Nuclear techniques have been used to develop a non-invasive solidification sensor for the metal casting industry, a sensor of great practical quality control and economic importance. Nuclear technologies have been used to eliminate E. coli bacteria from food and anthrax from our mail system.

**UNDERGRADUATE STUDY**

**Bachelor of Science in Nuclear Science and Engineering/Course 22**

The Department of Nuclear Science and Engineering’s undergraduate program offers a strong foundation in science-based engineering, providing the skills and knowledge for a broad range of technical careers. The nuclear energy industry is experiencing a major resurgence world-wide, leading to high demand for nuclear engineers. Other nuclear and radiation applications are increasingly important in medicine, industry, and government. The program provides fundamental knowledge both in engineering, including thermodynamics and thermal-hydraulics,
The Bachelor of Science in Nuclear Science and Engineering, Course 22, which is normally completed in four years.

A characteristic of the curriculum is to develop practical skills through hands-on education. This is accomplished through a laboratory course on radiation physics, measurement, and protection (22.09), and through the laboratory components and exercises in electronics (22.07), imaging (22.058), and computational courses. The concept of hands-on learning is continued with a 12-unit design course 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 and material applications).

Additional information may be obtained from the student’s departmental advisor or from the department’s Academic Office (Room 24-102).

The Bachelor of Science in Nuclear Science and Engineering prepares students for careers in the design, analysis, and operation of fission reactors, in various applications of radiation, and for graduate study in a wide range of engineering and physical sciences.

The Course 22 degree program is accredited by the Accreditation Board for Engineering and Technology.

Subject requirements and options are described in the preceding paragraphs and chart. A bachelor’s degree thesis of 12 units is required.

Minor in Nuclear Science and Engineering
The requirements for a Minor in Nuclear Science and Engineering 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 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 Principles of 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 profession is broad and many undergraduate disciplines provide suitable preparation for graduate study. While the graduate program splits into three areas after the initial core set of courses, many incoming students change their area of interest after joining the program. The Department of Nuclear Science and Engineering is dedicated to attracting a diverse class of well-prepared engineers and scientists.

An undergraduate degree in physics, engineering physics, chemistry, mathematics, metallurgy, or chemical, civil, electrical, mechanical, or nuclear science and engineering can provide a foundation for graduate study in nuclear science and engineering. Optimum undergraduate preparation would include the following:

Physics—at least three introductory courses covering classical mechanics, electricity and magnetism, and wave phenomena. An introduction to quantum mechanics is quite helpful, and an advanced course in electricity and magnetism (including a description of time-dependent fields via Maxwell’s equations) is recommended for those wishing to specialize in fusion.

Mathematics—it is essential that incoming students have a solid understanding of mathematics, including the study and application of ordinary differential equations. It is highly recommended that students also 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 skills, and incoming students are expected to have had an introduction to thermodynamics, fluid mechanics, heat transfer, electronics and measurement, and computation and numerical methods. A subject covering the mechanics of materials is recommended, particularly for students wishing to specialize in fission.
Laboratory experience is essential. This may have been achieved through an organized course, 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. Most master of science candidates specialize in one of three alternative fields: fission nuclear technology, applied plasma physics, or 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](http://student.mit.edu/catalog/index.cgi).

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://tppserver.mit.edu/](http://tppserver.mit.edu/).

**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.

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 courses (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 subjects 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 5 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 3). 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.

Within the Magnetic Resonance Laboratory, the full gamut of electron and nuclear magnetic resonance (NMR) techniques can be undertaken in one setting. Topics explored in the laboratory include NMR microscopy; studies of porous, granular, and soft matter; quantum chaos; coherent multi-body dynamics; and experimental implementation of quantum computers. A focus is on the engineering of quantum spin-based sensors, actuators, and computers.

The thermal hydraulics and nano-fluids 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.

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 and presentation 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.

FACULTY AND STAFF

Faculty and Teaching Staff

Richard Keith Lester, PhD
Professor of Nuclear Science and Engineering
Director, Industrial Performance Center
Department Head

Professors

George Apostolakis, PhD
KEPCO Professor of Nuclear Science and Engineering
Professor of Engineering Systems

Ronald George Ballinger, ScD
Professor of Nuclear Science and Engineering

David Grant Cory, PhD
Professor of Nuclear Science and Engineering

Michael Warren Golay, PhD
Professor of Nuclear Science and Engineering

Linn Walker Hobbs, DPhil
Professor of Materials Science and Nuclear Science and Engineering

Ian Horner Hutchinson, PhD
Professor of Nuclear Science and Engineering

Andrew C. Kadak, PhD
Professor of the Practice, Nuclear Science and Engineering

Mujid Suliman Kazimi, PhD
TEPCO Professor of Nuclear Engineering
Professor of Mechanical Engineering
Director, Center for Advanced Nuclear Energy Systems

Ronald Richard Parker, PhD
Professor of Electrical Engineering and Nuclear Science and Engineering

Jacquelyn Ciel Yanch, PhD
Professor of Nuclear Science and Engineering
MacVicar Faculty Fellow
Associate Professors
Jacopo Buongiorno, PhD
Carl R. Soderberg Associate Professor of Power Engineering
Associate Professor of Nuclear Science and Engineering
Alan Pradip Jasanoff, PhD
Associate Professor of Biological Engineering and Nuclear Science and Engineering
Dennis Whyte, PhD
Associate Professor of Nuclear Science and Engineering

Assistant Professors
Paola Cappellaro, PhD
Assistant Professor of Nuclear Science and Engineering and Computer Science
Benoit Forget, PhD
Assistant Professor of Nuclear Science and Engineering
Bilge Yildiz, PhD
Assistant Professor of Nuclear Science and Engineering

Senior Lecturers
Bruce R. Rosen, MD, PhD
Charles Forsberg, PhD

Research Staff
Senior Research Scientists
Peter Catto, PhD
Senior Research Scientist, Plasma Science and Fusion Center and Nuclear Science and Engineering
Daniel R. Cohn, PhD
Senior Research Scientist, Plasma Science and Fusion Center and Nuclear Science and Engineering
Head, Plasma Technology and Systems, Plasma Science and Fusion Center
Richard C. Lanza, PhD
Senior Research Scientist

Senior Research Engineer
Joseph V. Minervini, PhD
Head, Fusion Technology and Engineering, Plasma Science and Fusion Center
Senior Research Engineer, Plasma Science and Fusion Center and Nuclear Science and Engineering

Principal Research Engineer
John A. Bernard, Jr., PhD
Principal Research Engineer, Nuclear Reactor Laboratory and Nuclear Science and Engineering

Research Scientists
Thomas McKrell, PhD
Chandrasekhar Ramanathan, ScD

Research Engineers
Edward Pilat, PhD
Peter Stahle, BSME

Postdoctoral Associates
Jonathan Hodges, PhD
Khabiboulakh Katsiev, PhD
Hyung Dae Kim, PhD
Akirio Kushima, PhD
Marco Lagi, PhD
Dimitry Pushin, PhD

Research Affiliates
Piero Baglioni, PhD
Brandon Blackburn, PhD
Gongyin Chen, PhD
John Dobbs, PhD
Henry Foxhill, PhD
Pavel Hejzlar, ScD
Andrew Hodgdon, MSc
Michael Hynes, PhD
John Jackson, PhD
Shih-Ping Kao, PhD
Walter Kato, PhD
Genrich Krasko, PhD
Xi Lin, PhD
Qiao Liu, PhD
Francesco Mallamace, PhD
Shigenobu Ogata, PhD
David Perticone, PhD
Monica Regalbuto, PhD
Pradip Saha, PhD
Youssef Shatilla, PhD
Shuanghe Shi, PhD
Evgeni Shwageraus, PhD
Rodney Silva, MSc
Piero Tartaglia, PhD
Sebastian Teysserey, PhD
Terry Totemeier, PhD
Sergio Valenzuela, PhD
Dwight Williams, PhD
Richard Wright, PhD
Zhiwen Xu, PhD
Vitaliy Ziskin, PhD

Professors Emeriti
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
Elias Panayiotis Gytopoulos, 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
Kim Molvig, PhD
Associate Professor of 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.

Humanities, arts, and social science programs emphasize teaching, 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.

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 careers in universities and colleges, but also for government service, industry, and finance. The School also offers master’s degrees in Comparative Media Studies, Political Science, and Science Writing.

New Directions
Minor programs have been established in all of the School’s sections, programs, and departments, as well as in African and African Diaspora Studies, Applied International Studies, Chinese, Comparative Media Studies, East Asian Studies, European Studies, Latin American Studies, Middle Eastern Studies, Psychology, Russian 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 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 old 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.
Publications

*Soundings*, the magazine of the School of Humanities, Arts, and Social Sciences, is published twice a year in the spring and fall by the Dean’s Office Communications Team. For copies, contact the Office of the Dean, School of Humanities, Arts, and Social Sciences, Room E51-255.

Office of the Dean

Deborah K. Fitzgerald, PhD
Professor of the History of Technology
Kenan Sahin Dean

Kai von Fintel, PhD
Professor of Linguistics
Associate Dean

Marc B. Jones, MA
Assistant Dean for Finance and Administration

Anne Marie Michel, MA
Assistant Dean for Development

Susan Mannett, BA
Director of Human Resources for SHASS

Bette K. Davis, EdD
Director, Humanities, Arts, and Social Sciences Education Office

Emily Hiestand, MA
Senior Communications Officer

Degrees Offered in the School of Humanities, Arts, and Social Sciences

<table>
<thead>
<tr>
<th>Course</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>21A</td>
<td>Anthropology</td>
</tr>
<tr>
<td>CMS</td>
<td>Comparative Media Studies</td>
</tr>
<tr>
<td>14</td>
<td>Economics</td>
</tr>
<tr>
<td>21F</td>
<td>Foreign Languages and Literatures</td>
</tr>
<tr>
<td>21H</td>
<td>History</td>
</tr>
<tr>
<td>21*</td>
<td>Humanities</td>
</tr>
<tr>
<td>24</td>
<td>Linguistics and Philosophy</td>
</tr>
<tr>
<td>21L</td>
<td>Literature</td>
</tr>
<tr>
<td>21M</td>
<td>Music and Theater Arts</td>
</tr>
<tr>
<td>17</td>
<td>Political Science</td>
</tr>
<tr>
<td>STS</td>
<td>Program in Science, Technology, and Society</td>
</tr>
<tr>
<td>21W</td>
<td>Writing and Humanistic Studies</td>
</tr>
</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 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, as well as from the history and prehistory of those peoples.

The Anthropology program at MIT offers students a broad exposure to anthropological scholarship as well as perspectives on topics relevant to other fields in the humanities, social sciences, science, and engineering. It also provides more intensive introduction to areas of faculty specialization, which include 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 anthropology of medicine and scientific research. Geographical specializations include cultures of Africa, Latin America, the Caribbean, Asia, and the United States.

The anthropology curriculum is divided into seven groups that show the breadth of the field, with particular emphases. Introductory subjects range from 100 to 199. Social anthropology subjects that focus on specific topics are assigned to the 200 to 299 set. The subjects dealing with technology in cultural context, ranging from 300 to 399, focus on how technologies derive from and relate to their cultural settings. The next group, areal and historical studies, ranging from 400 to 499, includes subjects devoted to different regions and culture areas of the world. The series of subjects in the 500 to 599 group are advanced undergraduate subjects, intended primarily for majors and minors. The offerings ranging from 600 to 699 include special topics, seminars, and research subjects for undergraduates, and those ranging from 700 to 999 constitute advanced graduate subjects.

Students taking a concentration in anthropology should enroll in either 21A.100 Introduction to Anthropology or 21A.109 How Culture Works, and two other subjects. Anthropology subjects qualify for several interdisciplinary concentrations, including those in Women's and Gender Studies, Latin American Studies, and Technology, Culture, and Development.

**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 processes of meaning-making, the nature of anthropological fieldwork, and the connections between anthropology and the other social sciences. They study the various theories that attempt to explain human behavior as well as the range of methods anthropologists use to analyze data. Students can focus on geographical areas, such as Latin America or modern western society, and on issues like neocolonialism, ethnic conflict, human rights, expressive culture, or globalization.

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.

<table>
<thead>
<tr>
<th>Tier I</th>
<th>One subject:</th>
</tr>
</thead>
<tbody>
<tr>
<td>21A.100</td>
<td>Introduction to Anthropology</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>21A.109</td>
<td>How Culture Works</td>
</tr>
</tbody>
</table>

| Tier II | Four subjects with a unifying theme (not to include 21A.100 or 21A.109) |

<table>
<thead>
<tr>
<th>Tier III</th>
<th>One subject:</th>
</tr>
</thead>
<tbody>
<tr>
<td>21A.510</td>
<td>Seminar in Anthropological Theory</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>21A.512</td>
<td>Seminar in Ethnography and Fieldwork</td>
</tr>
</tbody>
</table>

**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.100 or 21A.109 is strongly recommended as a preliminary subject for all anthropology degree programs.

In collaboration, the Anthropology Program, the History faculty, and the Program in Science, Technology, and Society offer a Program in History, Anthropology, and Science, Technology and Society (HASTS) leading to the PhD; see the description under the Program in Science, Technology, and Society.

Subjects in anthropology are described in the 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 the Anthropology Office, Room 16-267, 617-253-3065.

**Faculty and Staff**

**Faculty and Teaching Staff**

Susan S. Silbey, PhD
Leon and Anne Goldberg Professor of Sociology and Anthropology
Section Head

**Professors**

Michael M. J. Fischer, PhD
Professor of Anthropology and Science and Technology Studies

James Howe, PhD
Professor of Anthropology
(On leave, fall)

Jean Elizabeth Jackson, PhD
Professor of Anthropology
MacVicar Faculty Fellow
### 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 (three subjects may 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</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Total GIr Subjects Required for SB Degree</strong></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).

<table>
<thead>
<tr>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>21A.100</strong> Introduction to Anthropology, 12, HASS-D</td>
<td>12</td>
</tr>
<tr>
<td><strong>21A.109</strong> How Culture Works, 12, HASS-D</td>
<td>12</td>
</tr>
<tr>
<td><strong>21A.510</strong> Seminar in Anthropological Theory, 12, HASS, CI-M</td>
<td>12</td>
</tr>
<tr>
<td><strong>21A.512</strong> Seminar in Ethnography and Fieldwork, 12, HASS, CI-M</td>
<td>12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Restricted Electives</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>90–96</td>
</tr>
</tbody>
</table>

#### Departmental Program Units That Also Satisfy the GIrs

(36)

<table>
<thead>
<tr>
<th>Unrestricted Electives</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>72–78</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.

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).
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.

UNDERGRADUATE STUDY

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.

ASSociate in Comparative Media Studies

Each student takes 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.820 Philosophy of Film
CMS.830 Studies in Film
CMS.835 Photography and Truth
CMS.836 The Social Documentary: Analysis and Production
CMS.837 Film, Music, and Social Change: Intersections of Media and Society
CMS.840 Literature and Film
CMS.841 Introduction to Videogame Studies
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.863 Computer Games and Simulations for Investigation and Education
CMS.864 Game Design
CMS.871 Media in Cultural Context
CMS.874 Visualizing Cultures
CMS.876 History of Media and Technology
CMS.882 Film, Fiction, and History in India, 1905–2005
CMS.888 Advertising and Popular Culture: East Asian Perspectives
CMS.910 Literature and Technology
CMS.915 Understanding Television
CMS.917 Documenting Culture
CMS.920 Popular 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
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 14N-207, 617-253-3599, fax 617-258-5133, cms@mit.edu.

Faculty and Staff
William Uricchio, PhD
Professor of Comparative Media Studies
Director
James Buzard, PhD
Professor of Literature
Section Head, Literature
Member, CMS Steering Committee
Shigeru Miyagawa, PhD
Kochi Prefecture-John Manjiro Professor of Japanese Language and Culture
Professor of Linguistics
Section Head, Foreign Languages and Literatures
Member, CMS Steering Committee
James Paradis, PhD
Robert M. Metcalfe Professor of Writing
Program Head, Writing and Humanistic Studies
Member, CMS Steering Committee
Janet Sonenberg, MFA
MacVicar Faculty Fellow
Section Head, Music and Theater Arts
Member, CMS Steering Committee

Faculty and Teaching Staff
Vivek Bald, PhD
Assistant Professor of Writing and Digital Media
Edward Barrett, PhD
Senior Lecturer in Writing
Christopher Capozzola, PhD
Associate Professor of History

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
21L.011 The Film Experience, 12, HASS-D, CI-H
CMS.100 Introduction to Media Studies, 12, HASS-D, CI-H
Tier II (Mid-tier)
Choose one of the following:
CMS.400 Media Systems and Texts, 12, HASS, CI-M; one subject in CMS or permission of instructor
CMS.405 Media and Methods: Performing, 12, HASS, CI-M; 21L.011, CMS.100, or permission of instructor
CMS.407 Media and Methods: Seeing and Expression, 12, HASS, CI-M; 21L.011 or CMS.100
Tier III (Capstone)
Choose one of the following:
21L.706 Studies in Film, 12, HASS, CI-M; 21L.011 and one subject in CMS or Literature; or permission of instructor
21L.715 Media in Cultural Context, 12, HASS, 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
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.
Beth Coleman, PhD
Assistant Professor of Writing and New Media

Ian Condry, PhD
Mitsui Career Development Associate Professor of Japanese Cultural Studies

Ellen Crocker, MA
Senior Lecturer in German

Junot Díaz, MFA
Associate Professor of Writing

Thomas F. DeFrantz, PhD
Class of 1948 Professor of Theater Arts

Peter Donaldson, PhD
Professor of Literature

Mary Fuller, PhD
Associate Professor of Literature

Gilberte Furstenberg, Agrégation
Senior Lecturer in French

Stefan Helmreich, PhD
Associate Professor of Anthropology

Diana Henderson, PhD
Professor of Literature
MacVicar Faculty Fellow

Wyn Kelley, PhD
Senior Lecturer in Literature

Alvin Kibel, PhD
Professor of Literature

Eric Klopfer, PhD
Associate Professor of Education
Director, Teacher Education Program

Martin Marks, PhD
Senior Lecturer in Music

Nick Montfort, PhD
Associate Professor of Digital Media

Douglas Morgenstern, MA
Senior Lecturer in Spanish

Jeffrey S. Ravel, PhD
Associate Professor of History

Jay Scheib, MFA
Associate Professor of Theater Arts

Irving Singer, PhD
Professor of Philosophy

David Thorburn, PhD
Professor of Literature
MacVicar Faculty Fellow
Director, MIT Communications Forum

Edward Baron Turk, PhD
Professor of French Studies and Film
John E. Burchard Professor of Humanities

Chris Walley, PhD
Associate Professor of Anthropology

Andrea Walsh, PhD
Lecturer in Writing and Humanistic Studies

Jing Wang, PhD
Professor of Chinese Cultural Studies
S. C. Fang Professor of Chinese Languages & Culture

**Visiting Lecturers**
Jesper Juul, PhD
Chris Weaver, MS

**Research Staff**

**Research Managers**

Kurt Fendt, PhD
Scot Osterweil, BA
Daniel Pereira, BA
Erin Reilly, MFA
Philip Tan, MS

**Postdoctorate Associates**

Joshua Green, PhD
Doris Rusch, 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
- Three subjects:
  - 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.

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.

*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 subject(s) for 14.01/14.02.

197
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>6</td>
<td>96–99</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>
<td>81–84</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>2</td>
<td>60</td>
</tr>
<tr>
<td>Laboratory Requirement [can be satisfied by 14.33 in the Departmental Program]</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

<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>14.01 Principles of Microeconomics, 12, HASS</td>
</tr>
<tr>
<td>14.02 Principles of Macroeconomics, 12, HASS</td>
</tr>
<tr>
<td>14.04 Intermediate Microeconomic Theory, 12, HASS; 14.01, Calculus II (GIR)</td>
</tr>
<tr>
<td>14.05 Intermediate Applied Macroeconomics, 12, HASS; 14.01, 14.02</td>
</tr>
<tr>
<td>14.30 Introductory 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)</td>
</tr>
<tr>
<td>Required Electives</td>
</tr>
<tr>
<td>Elective subjects in economics</td>
</tr>
</tbody>
</table>

Departmental Program Units That Also Satisfy the GIRs

| (60)                                                                                           |
|                                                                                               |
| Unrestricted Electives                                                                           | 81–84  |

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.

** 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.

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-dissertation 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.

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, phoag@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
Ricardo J. Caballero, PhD
Ford International Professor of Economics
Department Head
Glenn D. Ellison, PhD
Gregory K. Palm (1970) Professor of Economics
Associate Head

Professors
K. Daron Acemoglu, PhD
Charles P. Kindleberger Professor of Economics
George-Marios Angeletos, PhD
Professor of Economics
Joshua Angrist, PhD
Ford Professor of Economics
David Autor, PhD
Professor of Economics
Abhijit Banerjee, PhD
Ford International Professor of Economics
(On leave)
Olivier Blanchard, PhD
Class of 1941 Professor of Economics
(On leave)
Victor Chernozhukov, PhD
Professor of Economics
Peter A. Diamond, PhD
Professor of Economics
Institute Professor
Esther Duflo, PhD
Abdul Latif Jameel Professor of Poverty
Alleviation and Development Economics
Amy Finkelstein, PhD
Professor of Economics
Robert S. Gibbons, PhD
Sloan Distinguished Professor of Management
and Economics
Michael Greenstone, PhD
3M Professor of Environmental Economics
(On leave)
Jonathan Gruber, PhD
Professor of Economics
MacVicar Faculty Fellow
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
(On leave)
Paul L. Joskow, PhD
Elizabeth and James Killian Professor of Economics
and Management
(On leave)
Whitney K. Newey, PhD
Jane Berkowitz Carlton and Dennis William
Carlton Professor of Economics
Michael J. Piore, PhD
David W. Skinner Career Development Professor of Political Economy
James M. Poterba, DPhil
Mitsui Professor of Economics
Drazen Prelec, PhD
Digital Equipment Corporation Leaders for Manufacturing Professor of Management
Professor of Economics and Brain and Cognitive
Sciences
Nancy L. Rose, PhD
Professor of Economics
Stephen Ross, PhD
Franco Modigliani Professor of Finance and Economics
Richard L. Schmalensee, PhD
Gordon Y Billard Professor of Management and Economics
James Snyder, PhD
Arthur and Ruth Sloan Professor of Political Science and Economics
Lester C. Thurow, PhD
Jerome and Dorothy Lemelson Professor of Management and Economics
Robert Townsend, PhD
Elizabeth and James Killian Professor of Economics
Iván Werning, PhD
Professor of Economics
(On leave)
William C. Wheaton, PhD
Professor of Economics and Urban Studies
Director for Research, Center for Real Estate
Muhamet Yildiz, PhD
Professor of Economics
(On leave)

Associate Professors
Mikhail Golosov, PhD
Rudi Dornbusch Career Development Associate
Professor of Economics
Guido Lorenzoni, PhD
Pentti J. K. Kouri Career Development Associate
Professor of Economics
Ben Olken, PhD
Associate Professor of Economics

Assistant Professors
Arnaud Costinot, PhD
Assistant Professor of Economics
Dave Donaldson, PhD
Assistant Professor of Economics
Panle Jia, PhD
Assistant Professor of Economics
Mihai Manea, PhD
Assistant Professor of Economics
Anna Mikusheva, PhD
Castle Krob Career Development Assistant
Professor of Economics
(On leave)
Parag Pathak, PhD
Assistant Professor of Economics
Stephen P. Ryan, PhD
Silverman Family Career Development Assistant
Professor of Economics

Senior Lecturer
Sara Fisher Ellison, PhD

Visiting Professors
Hunt Allcott, PhD
Visiting Assistant Professor
Sandep Baliga, PhD
Visiting Associate Professor of Economics
Ernst Fehr, PhD
Visiting Professor of Economics
Francesco Giavazzi, PhD
Visiting Professor of Economics

Veronica Guerrieri, PhD
Visiting Assistant Professor of Economics

Gib Metcalf, PhD
Visiting Professor of Economics

Emmanuel Saez, PhD
Visiting Professor of Economics

Jean Tirole, PhD
Visiting Professor of Economics

Professors Emeriti
Morris A. Adelman, PhD
Professor of Economics, Emeritus

Robert L. Bishop, PhD
Professor of Economics, Emeritus

Richard S. Eckaus, PhD
Ford International Professor of Economics, Emeritus

Stanley Fischer, PhD
Professor of Economics, Emeritus

Frank Fisher, PhD

Jerome Rothenberg, PhD
Professor of Economics, Emeritus

Paul A. Samuelson, PhD, LLD, DLitt, ScD
Professor of Economics, Emeritus

Gordon Y Billard Fellow
Institute Professor, Emeritus

Abraham J. Siegel, PhD
Howard W. Johnson Professor of Management, Emeritus

Robert M. Solow, PhD, LLD, DLH
Professor of Economics, Emeritus

Institute Professor, Emeritus

Peter Temin, PhD
Elisha Gray II Professor of Economics, Emeritus
The Foreign Languages and Literatures Section offers a variety of programs. There are subject sequences in Chinese, French, German, Japanese, 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 Chinese III, (Regular)
or 21F.109 Chinese III, (Streamlined)
and
21F.104 Chinese IV, (Regular)
or 21F.110 Chinese IV, (Streamlined)
```

```
Tier II Two language subjects at the advanced level:
21F.105 Chinese V (Regular)
or 21F.113 Chinese V (Streamlined)
```  

```
and
```

```
21F.106 Chinese VI (Regular)
```

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.

Minor in French

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 French III
21F.304 French IV
```

```
Tier II Two or three subjects from the following intermediate subjects in French language, literature, and culture: 21F.308–21F.315
```

```
Tier III Two or three subjects from the following advanced subjects in French literature and culture: 21F.016, 21F.018, 21F.050, 21F.051, 21F.052, 21F.320–21F.348, 21H.346
```

Minor in German

The Minor in German consists of six subjects arranged into three levels of study as follows:

```
Tier I Two or three subjects from the following intermediate subjects in German language, literature, and culture: 21F.308–21F.315
```

```
Tier II Two or three subjects from the following advanced subjects in German language and culture: 21F.016, 21F.018, 21F.050, 21F.051, 21F.052, 21F.320–21F.348, 21H.346
```

Minor in Japanese

The Minor in Japanese consists of six subjects arranged into three levels of study as follows:

```
Tier I Two or three subjects in Japanese literature, history, or culture, at least one of which must be a Japanese Language Option subject, i.e. 21F.190, 21F.191, or 21F.192. The Japanese Language Option subjects meet with the three subjects 21F.036, 21F.046, and 21H.560, and include some assignments that require reading and writing in Japanese.
```

```
21F.030 East Asian Culture: From Zen to Pop
21F.036/21F.190 Advertising and Popular Culture: East Asian Perspectives
21F.038 The Cultural Politics of Contemporary China
21F.044 Traditional Chinese Literature
21F.045 Kung-Fu Cinema: Transnational Perspectives
21F.046/21F.192 Modern Chinese Fiction and Cinema
21H.504 East Asia in the World: 1500–2000 AD
21H.560/21F.191 Smashing the Iron Rice Bowl: Chinese East Asia
21H.580 From Silk Road to the Great Game: China, Russia, and Central Asia, 500–2000 AD
```

Minor in Spanish

The Minor in Spanish consists of six subjects arranged into three levels of study as follows:

```
Tier I Two or three subjects from the following intermediate subjects in Spanish language, literature, and culture: 21F.308–21F.315
```

```
Tier II Two or three subjects from the following advanced subjects in Spanish language, literature, and culture: 21F.016, 21F.018, 21F.050, 21F.051, 21F.052, 21F.320–21F.348, 21H.346
```

Minor in Russian

The Minor in Russian consists of six subjects arranged into three levels of study as follows:

```
Tier I Two or three subjects from the following intermediate subjects in Russian language, literature, and culture: 21F.308–21F.315
```

```
Tier II Two or three subjects from the following advanced subjects in Russian literature and culture: 21F.016, 21F.018, 21F.050, 21F.051, 21F.052, 21F.320–21F.348, 21H.346
```

Minor in Italian

The Minor in Italian consists of six subjects arranged into three levels of study as follows:

```
Tier I Two or three subjects from the following intermediate subjects in Italian language, literature, and culture: 21F.308–21F.315
```

```
Tier II Two or three subjects from the following advanced subjects in Italian literature and culture: 21F.016, 21F.018, 21F.050, 21F.051, 21F.052, 21F.320–21F.348, 21H.346
```

Minor in Portuguese

The Minor in Portuguese consists of six subjects arranged into three levels of study as follows:

```
Tier I Two or three subjects from the following intermediate subjects in Portuguese language, literature, and culture: 21F.308–21F.315
```

```
Tier II Two or three subjects from the following advanced subjects in Portuguese literature and culture: 21F.016, 21F.018, 21F.050, 21F.051, 21F.052, 21F.320–21F.348, 21H.346
```

Minor in Hebrew

The Minor in Hebrew consists of six subjects arranged into three levels of study as follows:

```
Tier I Two or three subjects from the following intermediate subjects in Hebrew language, literature, and culture: 21F.308–21F.315
```

```
Tier II Two or three subjects from the following advanced subjects in Hebrew literature and culture: 21F.016, 21F.018, 21F.050, 21F.051, 21F.052, 21F.320–21F.348, 21H.346
```

Minor in Arabic

The Minor in Arabic consists of six subjects arranged into three levels of study as follows:

```
Tier I Two or three subjects from the following intermediate subjects in Arabic language, literature, and culture: 21F.308–21F.315
```

```
Tier II Two or three subjects from the following advanced subjects in Arabic literature and culture: 21F.016, 21F.018, 21F.050, 21F.051, 21F.052, 21F.320–21F.348, 21H.346
```

Minor in Greek

The Minor in Greek consists of six subjects arranged into three levels of study as follows:

```
Tier I Two or three subjects from the following intermediate subjects in Greek language, literature, and culture: 21F.308–21F.315
```

```
Tier II Two or three subjects from the following advanced subjects in Greek literature and culture: 21F.016, 21F.018, 21F.050, 21F.051, 21F.052, 21F.320–21F.348, 21H.346
```
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 Laboratory Requirement 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 Units
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

Program 1: French Studies
Prerequisite subjects: 21F.301, 21F.302
Required Subjects 21F.304 French IV, 12, HASS-D Language Option, 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.315, 21F.320, 21F.336, 21F.341, 21F.343, 21F.345, 21F.346, or 21F.347.
Restricted Electives 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
Prerequisite subjects: 21F.701, 21F.702
Required Subjects 21F.704 Spanish IV, 12, HASS-D Language Option, 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.717, 21F.730, 21F.731, 21F.735, 21F.736, 21F.738, 21F.740, or 21F.742.
Restricted Electives 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 Units
(36)
Unrestricted Electives Program 1 48
Program 2 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.

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.
17.433 International Relations of East Asia
17.486 Japan and East Asian Security
17.537 Politics and Policy in Contemporary Japan
17.543 Japanese Politics and Society
21F.027J/21F.590 Visualizing Cultures
21F.030 East Asian Cultures: From Zen to Pop Culture
21F.063/21F.596 Anime: Transnational Media and Culture
21F.064/21F.592 Introduction to Japanese Culture
21F.065/21F.593 Japanese Literature and Cinema
21F.066/21F.594 Japan in Real Time
21F.067J/21F.595 Cultural Performances of Asia
21H.521 Ancient Japan and Courtly Society
21H.522 Japan in the Age of the Samurai: History and Film
21H.523 Emergence of the Modern Japanese State: 1800–1952
21H.546 World War II in Asia: Film, Fantasy, Fact

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 Spanish III
21F.704 Spanish IV
21F.705 Oral Communication in Spanish

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

Tier III Two subjects or more depending on demonstrated level of entering competence from the Spanish Advanced Subjects in Language and Culture listing: 21F.010, 21F.080, 21F.084J, 21F.716–21F.740

Please also refer to HASS Minors in Regional Studies in Part 3, which include Applied International Studies, East Asian Studies, European Studies, Latin American Studies, Middle Eastern Studies, African and African Diaspora Studies, and Russian Studies.

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.

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
Isabelle de Courtivron, PhD
Professor of French Studies
Ann F. Friedlaender Professor of the Humanities
MacVicar Faculty Fellow

Elizabeth Garrels, PhD
Professor of Spanish and Latin American Studies

Edward Baron Turk, PhD
Professor of French Studies and Film

John E. Burchard Professor of Humanities

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

T. T. and Wei Fong Professor of Asian Civilizations

Undergraduate Academic Officer

Senior Lecturers
Ellen Crocker, MA
Senior Lecturer in German

Jane Dunphy, MA
Senior Lecturer in English Language Studies

Gilberte Furstenberg, Agrégation
Senior Lecturer in French

Sabine Levet, MA
Senior Lecturer in French

Douglas Morgenstern, MA
Senior Lecturer in Spanish

Lecturers
Patricia Brennecke, MA
Lecturer in English Language Studies

Tong Chen, MA
Lecturer in Chinese

Cathy Culot, MA
Lecturer in French

Ricardo Gessa, MA
Lecturer in Spanish

Margarita Ribas Groeger, MA
Lecturer in Spanish

Dagmar Jaeger, PhD
Director, Spanish Language Studies

A. C. Kemp, MA
Lecturer in German

Min-Min Liang, MA
Lecturer in Japanese
Yoshimi Nagaya, MA
Lecturer
Director, Japanese Language Studies

Johann Sadock, PhD
Lecturer in French

Ikue Shingu, MA
Lecturer in Japanese

Lissette Soto, MA
Lecturer in Spanish

Peter Weise, PhD
Lecturer in German

Jin Zhang, MA
Lecturer in Chinese

Research Staff

Principal Research Associate
Kurt Fendt, PhD
Director, HyperStudio

Professors Emeriti
Catherine Vakar Chvany, PhD
Professor of Russian Studies, Emerita

James Wesley Harris, PhD
Professor of Spanish and Linguistics, 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, 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 HASS-D offerings, as well as one 21H elective seminar. Students are expected to take six 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 the Seminar in Historical Methods, which is intended to develop skills for independent research and writing, followed in the senior year by a Thesis Tutorial, and either a second major essay or a senior thesis. Supplementing these requirements within the history curriculum is the stipulation of three additional subjects in a second field of humanities, arts, and social sciences: anthropology, economics, political science, literature, foreign languages and literatures—fields 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:

- At least one 21H subject that is designated HASS-D
- At least one 21H elective seminar
- Three undergraduate elective subjects from the history curriculum
- 21H.931 Seminar in Historical Methods
- At least two temporal periods—one pre-modern (before 1700) and one modern—to be covered by the five subjects other than 21H.931

For a listing of available subjects, consult the History Office, Room E51-285, 617-253-4965.

Concentration in History

The Concentration in History will consist of three subjects, at least one and not more than two of which shall be selected from the 21H HASS-D designated offerings.

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 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 the History Office, Room E51-285, 617-253-4965.

Faculty and Staff

Faculty and Teaching Staff
Anne E. C. McCants, PhD
Professor of History
MacVicar Faculty Fellow
Section Head
(On leave, spring)

Professors
John W. Dower, PhD
Ford International Professor of History
Robert Michael Fogelson, PhD
Professor of History and Urban Studies
Philip S. Khoury, PhD
Ford International Professor of History
Associate Provost
Pauline Maier, PhD
William R. Kenan, Jr. Professor of History
Harriet Ritvo, PhD
Arthur J. Conner Professor of History
(On leave, fall)
Acting Section Head (Spring)
Merritt Roe Smith, PhD
Leverett and William Cutten Professor of the History of Technology
Craig Steven Wilder, PhD
Professor of History
Elizabeth A. Wood, PhD
Professor of History

Associate Professors
William Broadhead, PhD
Associate Professor of History
Christopher Capozzola, PhD
Associate Professor of History
Meg Jacobs, PhD
Associate Professor of History

Professor of History
Jeffrey S. Ravel, PhD
Associate Professor of History

Assistant Professors
Christopher R. Leighton, PhD
Assistant Professor of History
Haimanti Roy, PhD
Assistant Professor of History
### Bachelor of Science in History/Course 21H

#### 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 (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>
</tbody>
</table>

**Total GIR Subjects Required for SB Degree**

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<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>Subject</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>One 21H HASS-D subject (12 units)</td>
<td>57–60</td>
</tr>
<tr>
<td>One 21H seminar subject (9-12 units)</td>
<td></td>
</tr>
<tr>
<td>21H.931 Seminar in Historical Methods, 12, CI-M, HASS *</td>
<td></td>
</tr>
<tr>
<td>21H.ThT History Pre-Thesis Tutorial, 12</td>
<td></td>
</tr>
<tr>
<td>21H.ThU History Thesis, 12, CI-M *</td>
<td></td>
</tr>
</tbody>
</table>

#### Restricted Electives

A coherent program of six subjects from the history curriculum; and three related subjects from a second HASS discipline.

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>72–102</td>
</tr>
</tbody>
</table>

#### Departmental Program Units That Also Satisfy the GIRs

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>(27–33)</td>
</tr>
</tbody>
</table>

#### Unrestricted Electives

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>48–72</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>

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.
- 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).
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 (21E, 21S) or as full majors (major departure, Course 21), 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 majoring in German or completing a Course 21 major departure. 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
- East Asian Studies
- Latin American Studies
- Psychology
- Russian 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></td>
</tr>
<tr>
<td></td>
<td><strong>17</strong></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

<table>
<thead>
<tr>
<th>Requirement</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>
<tr>
<td><strong>Restricted Electives</strong></td>
<td><strong>126–162</strong></td>
</tr>
<tr>
<td><strong>German</strong></td>
<td></td>
</tr>
<tr>
<td>8 elective subjects in the field (which may include a pre-thesis and a thesis), plus a four-subject cluster</td>
<td></td>
</tr>
<tr>
<td>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.412, 21F.414, 21F.415, or 21F.416.</td>
<td></td>
</tr>
<tr>
<td><strong>Major Departures</strong></td>
<td></td>
</tr>
<tr>
<td>The restricted electives for the major departure fields are determined in consultation with the faculty advisor in the chosen field.</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
<tr>
<td><strong>Departmental Program Units That Also Satisfy the GIRs</strong></td>
<td><strong>27–36</strong></td>
</tr>
<tr>
<td><strong>Unrestricted Electives</strong></td>
<td><strong>45–90</strong></td>
</tr>
<tr>
<td><strong>Total Units Beyond the GIRs Required for SB Degree</strong></td>
<td><strong>180</strong></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**

(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/21E, Bachelor of Science in Humanities and Science/21S**

These joint degree programs combine humanities with scientific/engineering studies. Groups of subjects from the humanistic and technical areas are conjoined to yield a basic command of each mode of inquiry. One part is a selection from the undergraduate degree curriculum of a science or engineering department approved by a faculty member in the field. The other part consists of subjects in a humanities field, chosen by the student in consultation with an advisor from the appropriate humanities faculty. In most cases, a senior thesis or sequence of advanced seminars is also required.

This arrangement yields a humanities program of considerable depth while allowing for continued serious commitment to a scientific or engineering interest. Available humanities fields include:

- American Studies
- Ancient and Medieval Studies
- Anthropology
- Comparative Media Studies
- East Asian Studies
- Foreign Languages and Literatures (in French, German, or Spanish)
- History
- Latin American Studies
- Literature
- Music
- Psychology
- Russian Studies
- Science, Technology, and Society
- Theater Arts
- Women’s and Gender Studies
- Writing (Creative, Expository, Science Writing, or Technical Communication)

Faculty advisors in each discipline help students to arrange programs suited to both their interests and professional objectives. Any one of these fields may be joined with any science or engineering field to form a major. Some combinations naturally lend themselves not only to an understanding of each field but also to an integrative and comparative view of the relationship between the two.

### 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 (all but two Humanities, Arts, and Social Sciences Distribution subjects 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>
</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). 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.

### 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):

- **Anthropology**
  - Nine subjects including 21A.100 or 21A.109, 21A.510, and 21A.512. An honors thesis may be done at the invitation and approval of faculty. 102–108
- **Foreign Languages and Literatures (in French, German, or Spanish)**
  - Nine elective subjects, which may include a pre-thesis and thesis, subject to faculty approval. 81–102
- **History**
  - Seven elective subjects, a pre-thesis tutorial, and a thesis. 81–102
- **Literature**
  - Eight elective subjects (including two seminars and subjects in three historical periods or thematic complexes). 96
- **Music**
  - Eight 12-unit subjects, including 21M.220, 21M.301, 21M.302, 21M.500, one year (two 6-unit subjects) of performance, and three electives: one in Western or World music (21M.230–289 or 21M.291–299); one in theory/composition (21M.300–399), and one in history/literature, theory/composition, or performance (two 6-unit terms of 21M.401–499), to be selected in consultation with the major advisor. 96
- **Writing: Creative or Expository**
  - 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. 96–102
- **Writing: Science Writing or Technical Communication Studies**
  - Four subjects in writing (including 21W.777, 21W.778, 21W.792, and a subject in basic exposition), three subjects from related curricula (including, for Science Journalism, subjects in the history and social context of science/technology, or, for Technical Communication, 9.00, a subject in graphics and design, and a subject in the structure of business organizations), a pre-thesis tutorial, and a thesis. 90–102
- **American Studies**
  - Seven elective subjects (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. 81–102
- **Ancient and Medieval Studies**
  - Seven elective subjects (should follow the general structure of the Ancient and Medieval Studies Minor Program), a pre-thesis tutorial, and a thesis. 81–102
- **Comparative Media Studies**
  - Eight CMS subjects, including 21L.011 or CMS.100, one mid-tier subject (CMS.400, CMS.409, CMS.405, or CMS.407), one capstone subject (21L.706 or 21L.715), and five CMS electives. A pre-thesis tutorial (CMS.ThT) and thesis (CMS.ThU) may be substituted for one CMS elective. 81–102

### Distribution subjects

Distribution subjects can be satisfied by subjects in the Departmental Program.
East Asian Studies\(^{(1)}\)
Seven elective subjects (should follow the general structure of the East Asian Studies Minor program), a pre-thesis tutorial, and a thesis. 81–102

Latin American Studies\(^{(2)}\)
Introduction to Latin American Studies (21F.084J/17.55J/21A.224J) plus six elective subjects (including study in at least two disciplines and some work in Spanish or Portuguese language), a pre-thesis tutorial and a thesis. 81–102

Psychology\(^{(3)}\)
Nine elective subjects including 9.00 and approved by a faculty member in the field. 81–102

Russian Studies\(^{(3)}\)
Seven elective subjects (including Russian IV or equivalent), a pre-thesis tutorial, and a thesis. 81–102

Science, Technology, and Society (STS)
Eight subjects (including an STS HASS-D subject, STS.091, or STS.092), a pre-thesis tutorial, and a thesis. 90–108

Theater Arts\(^{(4)}\)
Eight subjects (including Script Analysis, Theater Practicum, and Stagecraft), a pre-thesis tutorial, and a thesis. 90–108

Women’s and Gender Studies\(^{(5)}\)
Seven subjects (including SP.401 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. 81–102

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.\(^{(3)}\)\(^{(6)}\) 54–72

For 21S
Six elective subjects restricted to one of the science curricula and approved by a faculty member in the field.\(^{(3)}\)\(^{(6)}\) 54–72

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
\(^{(3)}\) 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.
\(^{(4)}\) American Studies, Ancient and Medieval Studies, East Asian Studies, Latin American Studies, Psychology, Russian 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.
\(^{(5)}\) Russian language subjects are not offered at MIT, but may be taken at Harvard University or Wellesley College through cross-registration.
\(^{(6)}\) 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 of 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; facility 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.

**Bachelor of Science in Philosophy/Course 24-1**

<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>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences Requirement</td>
<td>[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>
<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).

**Required Subjects**

One HASS-D philosophy subject

One History of Philosophy subject:
- 24.01 Classics in Western Philosophy, 12, HASS-D, CI-H
- 24.201 Topics in the History of Philosophy, 12, HASS, CI-M *

One Knowledge and Reality subject:
- 24.09 Minds and Machines, 12, HASS-D, CI-H
- 24.111 Philosophy of Quantum Mechanics, 12, HASS
- 24.112 Space, Time, and Relativity, 12, HASS
- 24.114 A Philosophical History of Energy, 12, HASS
- 24.211 Theory of Knowledge, 12, HASS *
- 24.215 Topics in the Philosophy of Science, 12, HASS *
- 24.221 Metaphysics, 12, HASS, CI-M *
- 24.251 Introduction to Philosophy of Language, 12, HASS *
- 24.253 Philosophy of Mathematics, 12, HASS *
- 24.260 Foundations of Probability, 12, HASS *

One Value subject:
- 24.02 Moral Problems and the Good Life, 12, HASS-D, CI-H
- 24.04 Justice, 12, HASS-D, CI-H
- 24.06 Bioethics, 12, HASS-D, CI-H
- 24.120 Moral Psychology, 12, HASS, CI-M
- 24.209 Philosophy in Film and Other Media, 12, HASS
- 24.213 Philosophy of Film, 12, HASS
- 24.214 Introduction to Philosophy of the Arts, 12, HASS
- 24.223 Decisions, Games and Rational Choice, 12, HASS
- 24.231 Ethics, 12, HASS, CI-M *
- 24.235 Philosophy of Law, 12, HASS *
- 24.237 Feminist Theory, 12, HASS, CI-M *
- 24.263 The Nature of Creativity, 12, HASS, CI-M *

One Logic subject:
- 24.118 Paradox and Infinity, 12, HASS
- 24.241 Logic I, 12, HASS
- 24.242 Logic II, 12, HASS *
- 24.243 Classical Set Theory, 12, HASS *
- 24.244 Modal Logic, 12, HASS *

Restricted Electives

A coherent program of five additional subjects, of which two must be in philosophy.

To satisfy the requirement that students take two CI-M subjects, students must take 24.260 and one of the following: 24.120, 24.201, 24.221, 24.231, 24.237, or 24.263.

**Departmental Program Units That Also Satisfy the GIRs**

Unrestricted Electives

(36)
The Minor in Linguistics consists of six subjects arranged in three levels of study, intended to provide students with breadth in the field of theoretical linguistics as a whole. The three levels are as follows:

**Tier I**

**One subject:**

24.900 Introduction to Linguistics

**Tier II**

**Three non-introductory philosophy subjects, approved by the minor advisor**

24.901 Language and Its Structure I: Phonology
24.902 Language and Its Structure II: Syntax
24.903 Language and Its Structure III: Semantics and Pragmatics

**Tier III**

**One subject:**

24.910 Advanced Topics in Linguistic Analysis
24.914 Language Variation and Change
24.915 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/](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, morphology, syntax, semantics, and historical linguistics; but the program’s interests also extend into questions of the interrelations between linguistics and other disciplines such as philosophy and logic, literary studies, mathematics and the study of formal languages, acoustics, artificial intelligence, and computer science.

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 study of complex subject matter. Examples of such evidence might be mastery in depth of a language or group of languages, e.g., classical Greek, Semitic, Japanese; or work, academic or nonacademic, of high quality in a relevant area, especially if it requires considerable application, imagination, or ingenuity.

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, unless they have obtained adequate preparation elsewhere:

- 24.942 Topics in the Grammar of a Less Familiar Language
- 24.949 Introduction to Syntax
- 24.951 Introduction to Phonology
- 24.955 Workshop in Syntax and Semantics
- 24.961 Introduction to Phonology
- 24.962 Advanced Phonology
- 24.969 Workshop in Phonology and Morphology
- 24.970 Introduction to Semantics
- 24.973 Advanced Semantics
- 24.979 Topics in Semantics

Note that students are prohibited from majoring in both 24-1 and 24-2.

**Notes**

- *Prerequisites and corequisites are listed in the subject description.
- No more than four of the total number of philosophy subjects for the major may be HASS-D philosophy subjects.
- At least three of the total number of philosophy courses must be at the 200 level or above.
- May not also satisfy the departmental distribution requirement in philosophy.

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).
Before students begin their doctoral research, they are required to pass a comprehensive general examination consisting of two substantial papers on topics chosen in consultation with members of the faculty. 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.

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 are: knowledge and reality, experimental results, and interdisciplinary studies.

Restricted Electives

A coherent program of three additional subjects from linguistics, philosophy, or a related area.

Bachelor of Science in Linguistics and Philosophy/Course 24-2

<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>
</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>3</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></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

- **Linguistics Track**
  - 24.901 Language and Its Structure I: Phonology, 12, HASS *
  - 24.902 Language and Its Structure II: Syntax, 12, HASS, CI-M *
  - 24.903 Language and Its Structure III: Semantics and Pragmatics, 12, HASS *
  - 24.918 Workshop in Linguistic Research, 12, HASS, 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, CI-M *
  - 24.914 Language Variation and Change, 12, HASS-D, CI-M *
  - One of the following three Philosophy subjects: 24.09 Minds and Machines, 12, HASS-D, CI-H
  - 24.241 Logic I, 12, HASS
  - 24.251 Introduction to Philosophy of Language, 12, HASS *
  - One of the following five Experimental Results subjects:
    - 24.906J Language Acquisition, 12, HASS *
    - 24.903J Psycholinguistics, 12, HASS *
    - 24.905J The Linguistic Study of Bilingualism, 12, HASS, CI-H *
    - 24.907J Abnormal Language, 12, HASS *
    - 24.915J Linguistic Phonetics, 12, HASS *

- **Philosophy Track**
  - 24.09 Minds and Machines, 12, HASS-D, CI-H
  - 24.201 Topics in the History of Philosophy, 12, HASS, CI-M *
  - 24.241 Logic I, 12, HASS
  - 24.251 Introduction to the Philosophy of Language, 12, HASS *
  - 24.260 Topics in Philosophy, 12, HASS, CI-M *
  - One of the following Knowledge and Reality subjects:
    - 24.111J Philosophy of Quantum Mechanics, 12, HASS
    - 24.112J Space, Time, and Relativity, 12, HASS
    - 24.114J A Philosophical History of Energy, 12, HASS
    - 24.211J Theory of Knowledge, 12, HASS *
    - 24.215J Topics in the Philosophy of Science, 12, HASS *
    - 24.221J Metaphysics, 12, HASS, CI-M *
    - 24.235J Philosophy of Mathematics, 12, HASS *
    - 24.280J Foundations of Probability, 12, HASS *
  - One of the following three subjects:
    - 9.65 Cognitive Processes, 12, HASS *
    - 24.904J Language Acquisition, 12, HASS *
    - 24.905J Psycholinguistics, 12, HASS *

- **Restricted Electives**
  - 27–36

A coherent program of three additional subjects from linguistics, philosophy, or a related area.
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.

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
Irene Heim, PhD
Professor of Linguistics
Department Head

Professors
Alexander Byrne, PhD
Professor of Philosophy
(On leave)
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
Edward A. Gibson, PhD
Professor of Cognitive Science
Sally Haslanger, PhD
Professor of Philosophy
Richard Holton, PhD
Professor of Philosophy
Sabine Iatridou, PhD
Professor of Linguistics
(On leave, spring)
Michael Kenstowicz, PhD
Professor of Linguistics
Rae Langton, PhD
Professor of Philosophy
Vann McGee, PhD
Professor of Philosophy
(On leave, fall)
Shigeru Miyagawa, PhD
Kochi Prefecture-John Manjiro Professor of Japanese Language and Culture
Professor of Linguistics
Wayne O'Neil, PhD
Professor of Linguistics
David Pesetsky, PhD
Ferrari P. Ward Professor of Linguistics
MacVicar Faculty Fellow
Norvin Richards, PhD
Professor of Linguistics
Irving Singer, PhD
Professor of Philosophy
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

Associate Professors
Adam Albright, PhD
Associate Professor of Linguistics
Michel DeGraff, PhD
Associate Professor of Linguistics
Edward Flemming, PhD
Associate Professor of Linguistics
Martin Hackl, PhD
Associate Professor of Linguistics
Caspas Hare, PhD
Associate Professor of Philosophy
Agustín Rayo, PhD
Associate Professor of Philosophy
(On leave)
Roger White, PhD
Associate Professor of Philosophy

Assistant Professor
Bradford Skow, PhD
Assistant Professor of Philosophy
(On leave)

Professors Emeriti
Sylvain Bromberger, PhD
Professor of Philosophy, Emeritus
Richard Lee Cartwright, 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, Emeritus
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—both to traditional choices (e.g., journalism, law, and medical school) and to more esoteric ones, such as working 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, available online and from Literature Headquarters, Room 14N-407, offers detailed descriptions of all Literature subjects and includes specific information about required texts, writing assignments, and exams.

The Literature curriculum is arranged in four graduated categories:

- **Introductory subjects (21L.000–21L.017)** focus on major literary texts grouped in broad historical and generic sequences; most introductory subjects carry HASS-Distribution credit, and all carry Communication Intensive credit.
- **Sampling subjects (21L.310–21L.325)** are 6-unit subjects that provide both an alternative route into literary study and a less intensive means for students to sustain a commitment to reading and textual interpretation. Their focus is on critical exploration, textual comprehension, and group discussion, with less sustained attention to analytic writing skills. Students can combine two 6-unit Sampling subjects to count as a single 12-unit HASS Elective, equivalent to a subject in the Intermediate tier. No more than four Sampling subjects may be combined in this manner.
- **Intermediate subjects (21L.420–21L.512)** explore literary forms in greater depth and center on historical periods, literary themes, or genres.
- **Seminar subjects (21L.701–21L.715)**—usually restricted to students who have taken at least two previous subjects in Literature—encourage a greater degree of independent work, such as oral reports and other special projects. Enrollment in seminars is strictly limited to a maximum of 12 students.

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 popular culture, media and film studies, 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.017

- **Tier II Intermediate Level**  
  Two or three subjects from 21L.420–21L.512; Note: two samplings subjects (21L.310–21L.325) may be substituted 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 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.

**Faculty and Staff**

**Faculty and Teaching Staff**

James Buzard, PhD  
Professor of Literature  
Section Head

**Professors**

Peter S. Donaldson, PhD  
Professor of Literature
## Bachelor of Science in Literature/Course 21L

<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>[three subjects can be satisfied by subjects in the</td>
<td></td>
</tr>
<tr>
<td>Departmental Program]</td>
<td></td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST)</td>
<td>2</td>
</tr>
<tr>
<td>Requirement</td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>1</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);
- 2 subjects designated as Communication Intensive in the Major (CI-M).

### PLUS Departmental Program (27–36)
- Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).
- Required Subjects: Three seminar level subjects.
- To satisfy the requirement that students complete two Communication Intensive subjects in the major, students must take two subjects from this list of approved CI-M subjects for Course 21L: 21L.473J, 21L.701, 21L.702, 21L.703, 21L.704, 21L.705, 21L.706, 21L.707, 21L.708, 21L.709.
- Restricted Electives: A coherent program of seven additional subjects from the literature curriculum (see above).
- Departmental Program Units That Also Satisfy the GIRs: 36
- Unrestricted Electives: 63–84
- **Total Units Beyond the GIRs Required for SB Degree** 180

### Notes
- 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.
- 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).

### Faculty Members
- **Associate Professors**
  - Mary C. Fuller, PhD
  - Noel B. Jackson, PhD
  - Homer A. Burnell Career Development Associate
  - Shankar Raman, PhD
- **Assistant Professors**
  - Sandy Alexandre, PhD
  - Arthur W. Bahr, PhD
  - Shankar Raman, PhD
- **Associate Professors**
  - Mary C. Fuller, PhD
  - Noel B. Jackson, PhD
  - Homer A. Burnell Career Development Associate
- **Senior Lecturer**
  - John Picker, PhD
- **Lecturers**
  - Howard Eiland, PhD
  - Ina Lipkowitz, PhD
- **MLK Artist/Scholar**
  - Ricardo Pitts-Wiley
- **Professors Emeriti**
  - Albert Ramsdell Gurney, Jr., MFA
  - Irene Taylor, PhD

### Departmental Program Units That Also Satisfy the GIRs (27–36)
- Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

### 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).
**MUSIC**

The Music Program offers a broad range of opportunities to experience and explore the field of music. A great variety of subjects is offered, ranging from Fundamentals of Music to Senior Seminar for Music Majors. The subjects are arranged into six categories: introductory, history/literature, theory/composition, performance, special topics/advanced subjects, and music/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 some performance and special topics/advanced subjects.

The symphony orchestra, choral groups, wind and jazz ensembles, chamber music groups, and gamelan and rambax 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 some performance groups and private study.

Twenty-three professors and lecturers who specialize in composition, performance, music theory, and music history offer a wide variety of classes, which form our Music Program.

**Bachelor of Science in Music/Course 21M**

The undergraduate program leading to the degree of Bachelor of Science in Music is concerned with a confluence of three basic areas: a thorough grounding in the harmony and counterpoint of Western music; in-depth studies in the history and repertoire of Western and World music; and performing experience in small and/or large ensembles. Six required subjects (one of which consists of two terms of performance) and four electives (which must include subjects from three different areas) form the core of the program, which can be supplemented by eight unrestricted electives (for 96 additional units). 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. Students who declare music as their major must ordinarily 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 musical activity: performance, composition, and history. The four subjects in Tiers I and II are at the introductory or intermediate level. Those in Tier III 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, one from each of the following areas:
    - History/Literature: 21M.226, 21M.201–299
    - Theory/Composition: 21M.301
    - 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 both fields. The joint major requires four subjects (21M.220, 21M.301, 21M.302, and 21M.500), two terms of performance subjects, electives in two musical fields (usually composition and history), a 12-unit elective in any musical field (composition, history, or two terms of performance), and six elective subjects in an engineering or science curriculum.

**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 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 imaginatively but constructively 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. The Minor in Theater Arts consists of the equivalent of six subjects arranged in three levels of study as follows:

- **Tier I**
  - Analysis and Theory
    - One subject from the following:
      - 21M.616 Learning from the Past: Drama, Science, Performance
      - 21M.617 Science and Theatrical Imagination
      - 21M.621 Theater and Cultural Diversity in the US

  NB: Joint as well as full majors may, with faculty approval, substitute three full years of Advanced Musical Performance (21M.480) and
Bachelor of Science in Music/Course 21M

**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</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>[three subjects can be from the Departmental Program]</td>
<td></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>
</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>21M.220 Early Music, 12, HASS, CI-M; 21M.011*</td>
<td>72</td>
</tr>
<tr>
<td>21M.301 Harmony and Counterpoint I, 12, HASS-D; 21M.051*</td>
<td></td>
</tr>
<tr>
<td>21M.302 Harmony and Counterpoint II, 12, HASS; 21M.301</td>
<td></td>
</tr>
<tr>
<td>21M.303 Writing in Tonal Forms I, 12, HASS; 21M.302</td>
<td></td>
</tr>
<tr>
<td>21M.350 Musical Analysis, 12, HASS; 21M.302*</td>
<td></td>
</tr>
</tbody>
</table>

Two terms of Performance subjects, 21M.401–21M.499 (6 units each)

**21M.500 Senior Seminar in Music, 12, HASS, CI-M; 21M.302, two 21M.2xx subjects**

**Restricted Electives**

48

Four electives, consisting of one subject from each category below (12 units each):

- **Theory/composition (21M.300–21M.399)**
- **Western music (21M.226–21M.289)**
- **World music (21M.291–21M.299)**
- **Choice of theory/composition, history/literature, or two terms of performance to be selected in consultation with the major advisor**
- **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

*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 of the MIT Subject Listing & Schedule, [http://student.mit.edu/catalog/index.cgi](http://student.mit.edu/catalog/index.cgi).

Subjects in theater arts are described in the online MIT Subject Listing & Schedule, [http://student.mit.edu/catalog/index.cgi](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.
FACULTY AND STAFF

Faculty and Teaching Staff

Ellen T. Harris, PhD
Class of 1949 Professor of Music
Section Head, spring

Janet Sonenberg, MFA
Professor of Theater Arts
MacVicar Faculty Fellow
Section Head, fall
(On leave, spring)

Professors

Alan Brody, PhD
Professor of Theater Arts

Peter Child, PhD
Professor of Music
MacVicar Faculty Fellow

Thomas F. DeFrantz, PhD
Class of 1948 Professor of Theater Arts

John Harbison, MFA
Professor of Music
Institute Professor

Lowell Edwin Lindgren, PhD
Professor of Music

Marcus Aurelius Thompson, DMA
Robert R. Taylor Professor of Music
(On leave, spring)

Barry Lloyd Vercoe, DMA
Professor of Media Arts and Sciences

Evan Ziporyn, PhD
Kenan Sahin Distinguished Professor of Music
(On leave, fall)

Associate Professors

Keeril Makan, PhD
Associate Professor of Music

Jay Scheib, MFA
Associate Professor of Theater Arts

Patricia J. Tang, PhD
Associate Professor of Music
(On leave, spring)

Assistant Professor

Michael Cuthbert, PhD
Assistant Professor of Music
(On leave)

Senior Lecturers

David Deveau, MM
Senior Lecturer in Music

Martin Marks, PhD
Senior Lecturer in Music

Michael Ouellette, MFA
Senior Lecturer in Theater Arts

George Ruckert, PhD
Senior Lecturer in Music

Charles Shadle, PhD
Senior Lecturer in Music

Pamela Sharon Wood, MM
Senior Lecturer in Music

Lecturers

Adam Boyles, DMA
Lecturer in Music
Director, Orchestra

Sara Brown, MFA
Lecturer in Theater Arts
Director of Design

William C. Cutter, DMA
Lecturer in Music
Director, Choral Programs

Frederick Harris, PhD
Lecturer in Music
Director, Wind Ensembles
(On leave, fall)

Mark Harvey, PhD
Lecturer in Music

Kim Mancuso, MFA
Lecturer in Theater Arts

Theresa Neff, PhD
Lecturer in Music

Jean Rife, BM
Lecturer in Music

Elena L. Ruehr, PhD
Lecturer in Music

Peter Whincop, MA
Lecturer in Music

Instructors

Leslie Cocuzzo Held, BA
Technical Instructor in Theater Arts

Michael Katz, MFA
Technical Instructor in Theater Arts

Karen Perlow, BA
Technical Instructor in Theater Arts

Professors Emeriti

Jeanne Shapiro Bamberger, MA
Professor of Music, Emerita

Stephen Erdely
Professor of Music, 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 their 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)

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:

17.811 Game Theory and Political Process

17.820 Introduction to the American Political Process

17.40 American Foreign Policy

17.50 Introduction to Comparative Politics

17.477J Technology and Policy of Weapons Systems

17.495 Globalization

17.440 Politics and Conflict in the Middle East

17.195 Justice

17.20 Introduction to the American Political Process

17.40 American Foreign Policy

17.50 Introduction to Comparative Politics

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 HASS Education Office, Room 14N-410.

Minor in 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.
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.

Accelerated Master of Science in Political Science
The department offers a five-year program leading to the Bachelor of Science and Master of Science, awarded simultaneously. This program is open to MIT undergraduates only. It allows the student to plan for a 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 (for specifics see the department handbook):
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 and oral general exam. 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.

FACULTY AND STAFF

Faculty and Teaching Staff
Charles Stewart III, PhD
Kenan Sahin Distinguished Professor
Professor of Political Science
Department Head

Professors
Stephen Ansolabehere, PhD
Elting E. Morison Professor of Political Science
(On leave)
Suzanne Berger, PhD
Raphael Dorman and Helen Starbuck Professor of Political Science
Nazli Choucri, PhD
Professor of Political Science
Richard M. Locke, PhD
Alvin J. Siteman Professor of Entrepreneurship and Political Science
Michael Joseph Piore, PhD
David W. Skinner Professor of Political Economy and Political Science
Barry R. Posen, PhD
Ford Foundation International Professor of Political Science
Director, Security Studies Program
(On sabbatical)
Richard J. Samuels, PhD
Ford International Professor of Political Science
Director, Center for International Studies
Ben Ross Schneider, PhD
Professor of Political Science
James M. Snyder, Jr., PhD
Arthur and Ruth Sloan Professor of Political Science and Economics
(On leave, spring)
Kathleen Thelen, PhD
Ford Professor of Political Science
Stephen W. Van Evera, PhD
Ford International Professor of Political Science

Associate Professors
Adam Berinsky, PhD
Associate Professor of Political Science
(On sabbatical)
Andrea Campbell, PhD
Alfred Henry and Jean Morrison Hayes Career Development Associate Professor of Political Science
Taylor Fravel, PhD
Cecil and Ida Green Career Associate Professor of Political Science
(On leave, fall)

Orit Kedar, PhD
Associate Professor of Political Science
(On leave)
Chappell H. Lawson, PhD
Associate Professor of Political Science
Melissa Nobles, PhD
Associate Professor of Political Science
Kenneth A. Oye, PhD
Associate Professor of Political Science
Roger Petersen, PhD
Associate Professor of Political Science
Edward Steinfeld, PhD
Associate Professor of Political Science
Lily Tsai, PhD
Associate Professor of Political Science

Assistant Professors
Fotini Christia, PhD
Assistant Professor of Political Science
(On leave)
Jens Hainmueller, PhD
Assistant Professor of Political Science
Gabriel Lenz, PhD
Assistant Professor of Political Science
(On leave, fall)
David Andrew Singer, PhD
Assistant Professor of Political Science

Professors Emeriti
Donald L. M. Blackmer, PhD
Professor of Political Science, Emeritus
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
George W. Rathjens, PhD
Professor of Political Science, Emeritus

Associate Professors
Adam Berinsky, PhD
Associate Professor of Political Science
(On sabbatical)
Andrea Campbell, PhD
Alfred Henry and Jean Morrison Hayes Career Development Associate Professor of Political Science
Taylor Fravel, PhD
Cecil and Ida Green Career Associate Professor of Political Science
(On leave, fall)

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

Engineering and science 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 science and engineering students to broad social and intellectual perspectives on their 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.

Most STS undergraduate subjects count toward the Institute Requirement in the Humanities, Arts, and Social Sciences. The program offers a number of HASS Distribution Requirement subjects and CI-H subjects, as well as a field of concentration.

Minor in Science, Technology, and Society

The goal of the minor program is to give students majoring in engineering or one of the sciences a broader perspective on their fields: 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 subjects as follows:

Tier I  One HASS-D subject in STS

Tier II  Four undergraduate STS subjects forming a coherent group relevant to the student's major Course of study

Tier III  One Capstone Seminar in STS (STS.091 or STS.092). Prerequisite is completion of one STS HASS-D subject or permission of the STS undergraduate advisor.

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.

Students in the double major program must complete all the requirements of their majors as well as the STS requirements described below. They must also write a thesis in each field.

The STS requirements include 14 subjects as follows: one STS HASS-D subject; six other STS subjects; one Capstone seminar (STS.091 or STS.092); pre-thesis tutorial; the thesis; and four related HASS subjects forming a coherent group. Further details on the requirements of this double major may be obtained from the Department of Humanities and the STS undergraduate advisor.

Joint Degree Program

Students who wish to integrate studies in STS and science or engineering in the context of a single degree program should consider this program. It includes a group of specially designated subjects offered by STS that provide a focus for interdisciplinary work. Central to this core is a capstone seminar (STS.091 or STS.092) that examines interactions of science, technology, and culture through reading, writing, and discussion of major works.

Students who take this degree must complete 10 subjects: one STS HASS-D subject; six other STS subjects; one STS Capstone seminar in STS (STS.091 or STS.092); pre-thesis tutorial; and thesis.

Consult the 21E/21S degree chart for details on the requirements for this joint degree. Further details may be obtained from the Department of Humanities and the STS undergraduate advisor.

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 take at least 10 subjects in the doctoral program during their first two years. Normally, all students take the required introductory seminars, STS.210J, STS.250J, and STS.260, in their first term. Students are encouraged to take STS.380J and STS.390 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.

Upon the satisfactory completion of general examinations in the third year, students proceed to the writing of a 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 E51-185, 617-253-9759.
Bachelor of Science in Science, Technology, and Society/Double Major/
Course STS (1)

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 39
One STS HASS-D subject of at least 12 units
STS.091 Capstone Seminar in STS Studies I, 9, HASS, CI-M *
STS.092 Capstone Seminar in STS Studies II, 9, HASS, CI-M *
STS.ThT Undergraduate Thesis Tutorial, 6
STS.ThU Undergraduate Thesis, 12, CI-M *

Restricted Electives 90–120
A coherent group of six elective subjects in STS.
Four related subjects in humanities, arts, and social sciences (three of which can be satisfied by HASS GIrs).

Departmental Program Units That Also Satisfy the GIrs (30)

Unrestricted Electives 48–81

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.

(1) 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.

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.

Inquiries
Additional information on the Program in Science, Technology, and Society may be obtained from the STS academic administrator, Room E51-185, 617-253-9759, http://web.mit.edu/sts/.

For detailed descriptions of subjects in Science, Technology, and Society, see the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.

Faculty and Teaching Staff

Faculty and Teaching Staff
David A. Mindell, PhD
Frances and David Dibner Professor of the History of Engineering and Manufacturing
Professor of Engineering Systems
MacVicar Faculty Fellow
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

Theodore A. Postol, PhD
Professor of Science, Technology, and National Security Policy

Merritt Roe Smith, PhD
Leverett Howell and William King Cutten Professor of the History of Technology
Undergraduate Faculty Advisor

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
David S. Jones, PhD, MD
Associate Professor of the History and Culture of Science and Technology
MacVicar Faculty Fellow
David Kaiser, PhD
Associate Professor of the History of Science
Lecturer in Physics

Assistant Professors
Vincent Lépinay, PhD
Assistant Professor of Science, Technology, and Society
Clapperton Mavhunga, PhD
Assistant Professor of Science, Technology, and Society
Natasha Schüll, PhD
Leo Marx Career Development Assistant Professor of Science, Technology, and Society
Hanna Shell, PhD
Assistant Professor of Science, Technology, and Society

Adjunct Professor
John Durant, PhD
Adjunct Professor of Science, Technology, and Society

Visiting Professors
Manuel Castells, PhD
Distinguished Visiting Professor of Technology and Society
Jill Ker Conway, PhD
Professor of the History of Women
Thomas P. Hughes, PhD
Distinguished Visiting Professor of the History of Technology

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
Carl Kaysen, PhD
David W. Skinner Professor of Political Economy, 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
Charles Weiner, PhD
Professor of the History of Science and Technology, 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, and 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/ Course 21W
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 One subject from the following:
21W.730 Writing on Contemporary Issues
21W.731 Writing and Experience
21W.732 Science Writing and New Media
21W.734J Writing About Literature
21W.735 Writing and Reading Short Stories
21W.756 Writing and Reading Poems

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 semester 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.

Writing Across the Curriculum
The Writing Across the Curriculum (WAC) staff of the Program in Writing and Humanistic Studies helps provide the integration of instruction and
Bachelor of Science in Writing/Course 21W

General Institute Requirements (GIRs) | Subjects | Units
--- | --- | ---
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
--- | ---
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 | 18
---
21W.ThT Writing and Humanistic Studies Pre-Thesis Tutorial, 6
21W.Thu Writing and Humanistic Studies Thesis, 12, CI-M; 21W.ThT
One of the following (CI-M): 21W.755, 21W.758, 21W.759, 21W.762, 21W.766I, 21W.770, 21W.771, 21W.777, or 21W.Thu

Restricted Electives | 90–120
Seven 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 | 54
---
21W.778 Science Journalism, 12, HASS, CI-H
21W.792 Science Writing Internship, 12, HASS
21W.ThT Writing and Humanistic Studies Pre-Thesis Tutorial, 6
21W.Thu Writing and Humanistic Studies Thesis, 12, CI-M; 21W.ThT
One of the following (CI-M): 21W.755, 21W.758, 21W.759, 21W.762, 21W.766I, 21W.770, 21W.771, 21W.777, or 21W.Thu

Restricted Electives | 60
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 (48 units).
One approved Science, Technology, and Society subject (12 units).

Option 3: Digital Media
Required Subjects | 54
---
21W.764 The Word Made Digital, 12, HASS
21W.765 I Interactive and Non-Linear Narrative: Theory and Practice, 12, HASS
21W.785 Communicating with Web-based Media, 12, HASS, CI-H
21W.ThT Writing and Humanistic Studies Pre-Thesis Tutorial, 6
21W.Thu Writing and Humanistic Studies Thesis, 12, CI-M; 21W.ThT
One of the following (CI-M): 21W.755, 21W.758, 21W.759, 21W.762, 21W.766I, 21W.770, 21W.771, 21W.777, or 21W.Thu

Restricted Electives | 63–84
Four subjects in writing, which may be in digital media, creative writing, or science writing, and three related subjects from any of the following courses: 6, 21L, MAS, STS, or CMS

Departmental Program Units That Also Satisfy the GIRs
(27–36)

Unrestricted Electives
Option 1 | 42–72
Option 2 | 66
Option 3 | 42–63

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
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.

Feedback in writing and speaking in subjects in all undergraduate departments and programs. The writing tutor program supports enhanced writing instruction in Communication Intensive in Humanities, Arts, and Social Sciences (CI-H) subjects. WAC lecturers collaborate with faculty in all schools in the teaching of Communication Intensive in the Major (CI-M) subjects.

Subjects in writing are described in the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi. Further information on subjects and programs may be obtained from the Program in Writing and Humanistic Studies Office, Room 14E-303, 617-253-7894.

FacultY and Staff

Faculty and Teaching Staff
James Paradis, PhD
Robert M. Metcalfe Professor of Writing

Professors
Junot Díaz, MFA
Professor of Writing
Robert Kanigel, BS
Professor of Science Writing
Thomas Levenson, BA
Professor of Science Writing
Kenneth R. Manning, PhD
Thomas Meloy Professor of Rhetoric and the History of Science
James H. Williams, Jr., PhD
SEPTE Professor of Engineering
Charles F. Hopewell Faculty Fellow
Rosalind H. Williams, PhD
Bern Dibner Professor of the History of Science and Technology

Associate Professors
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
Beth Coleman, PhD
Assistant Professor of Writing and New Media

Adjunct Professors
Marcia Bartusiak, MS
Adjunct Professor of Science Writing
Joe Haldeman, MFA
Adjunct Professor of Fiction
Alan Lightman, PhD
Adjunct Professor of the Humanities

Senior Lecturer
Edward Barrett, PhD
Senior Lecturer in Writing

Lecturers
Cherie Abbanat, MA
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
Director, Student Writing Activities

Jennifer Craig, MA
David Custer, BA
Kathleen Delaney, PhD
Nora Delaney, MA
Thomas Delaney, MA
Lisa Dush, MA
Rebecca Faery, PhD
Director, First Year Writing

Elizabeth Fox, PhD
Erica Funkhouser, MA
JoAnn Graziano
William Haas, PhD
Gay Haldeman, MA
Elizabeth Harris, MA
Louise Harrison-Lepera, MA
Diane Hendrix, MA
Philip J. Hilts
Robert Irwin, PhD
Nora Jackson, MA
Neal Lerner, EdD
Marilyn Levine, MA
Shariann Lewitt, MFA
Lucy Marx, MA

Janis Melvold, PhD
Benjamin Miller, PhD
Marilee Ogren-Balkema, PhD
Karen Pepper, PhD

Mya Poe, PhD
Director, Technical Communication

Kym Ragusa, MFA
Leslie Ann Sulit Roldan, PhD
Thalia Rubio, MEd
Susan Ruff, BA
Pamela Siska, ABD
Amanda Sobel, MA
Susan Spilecki, MA
Cynthia Taft, PhD
Donald Unger, PhD
Kim Vaeth, MA
Lydia Volaitis, PhD
Andrea Walsh, PhD
Jeanne Wildman, JD

Research Staff

Senior Research Scientist
Sonal Jhaveri, PhD

Research Associate
Philip Alexander, MS

Professors Emeriti
Anita Desai, BA
John E. Burchard Professor of Humanities, Emerita

Robert Reynolds Rathbone, AM
Professor of Technical Communication, 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 principled, 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. It also conducts pioneering research in the management of technology and offers the nation’s leading master’s program for executives in this important area. Recently, MIT Sloan launched an exciting executive education program, Leading Innovative Enterprise: Strategies for Growth in the Life Sciences.

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 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:

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, the Sungkyunkwan University in Korea, 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 developments and challenges.

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 32 Chinese international MBA students and 24 MIT Sloan
students, the inaugural China Lab incorporated 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.

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/.

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/, that provides access to a rich and detailed range of news and information about the School, its activities, and its resources.

Degrees Offered in the MIT Sloan School of Management

<table>
<thead>
<tr>
<th>Management</th>
<th>Course 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB</td>
<td>Management Science</td>
</tr>
<tr>
<td>MBA</td>
<td>Master of Finance</td>
</tr>
<tr>
<td>MFin</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>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operations Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
</tr>
<tr>
<td>PhD</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Systems Design and Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
</tr>
</tbody>
</table>

Note: Many departments make it possible for a graduate student to pursue a simultaneous master’s degree.

(i) 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.

(ii) 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
Robert Michael Freund, PhD
Theresa Seley Professor of Management Science
Deputy Dean
Richard M. Locke, PhD
Alvin J. Sitemap (1948) Professor of Entrepreneurship
Professor of Political Science
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
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 General Institute Requirements with subjects at the MIT Sloan School of Management, students learn a unique combination of technical and managerial skills that 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 computer technology, methods for collecting and structuring large quantities of data, mathematical programming, and the building of sophisticated mathematical models. The MIT Sloan School's undergraduate degree program develops necessary expertise in the underlying disciplines of mathematical programming and modeling, 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 selects a concentration of four subjects in finance, information technologies, marketing science, or operations research.

MIT Sloan undergraduates take most management electives at the graduate level, 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 provides undergraduates in other majors with an understanding of the economic, business, human, social, and organizational dimensions of scientific and technological enterprise.

The minor consists of six subjects, four required:

**General Institute Requirements (GIRs)**

- **Science Requirement**
  - 14.01 Principles of Microeconomics, 12, HASS
  - 14.02 Principles of Macroeconomics, 12, HASS

- **Restricted Electives in Science and Technology (REST) Requirement**
  - 6.041 Probabilistic Systems Analysis, 12, REST; Calculus II (GIR)
  - 15.075 Statistical Thinking and Data Analysis, 12; 6.041*

- **Laboratory Requirement**
  - 15.301 Managerial Psychology Laboratory, 15, LAB, CI-M

**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>1.00 Introduction to Computers and Engineering Problem Solving, 12, REST; Calculus I (GIR)</td>
<td>123</td>
</tr>
<tr>
<td>6.041 Probabilistic Systems Analysis, 12, REST; Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td>14.01 Principles of Microeconomics, 12, HASS</td>
<td></td>
</tr>
<tr>
<td>14.02 Principles of Macroeconomics, 12, HASS</td>
<td></td>
</tr>
<tr>
<td>15.053 Optimization Methods in Management Science, 12</td>
<td></td>
</tr>
<tr>
<td>15.075 Statistical Thinking and Data Analysis, 12; 6.041*</td>
<td></td>
</tr>
<tr>
<td>15.279 Management Communication for Undergraduates, 12, CI-M</td>
<td></td>
</tr>
<tr>
<td>15.301 Managerial Psychology Laboratory, 15, LAB, CI-M</td>
<td></td>
</tr>
<tr>
<td>15.501 Corporate Financial Accounting, 12</td>
<td></td>
</tr>
<tr>
<td>18.06 Linear Algebra, 12, REST; Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td>Restricted Electives</td>
<td>36–45</td>
</tr>
<tr>
<td>One of the following four subjects:</td>
<td></td>
</tr>
<tr>
<td>15.354 Innovation and Entrepreneurship: How to Do It, 9</td>
<td></td>
</tr>
<tr>
<td>15.401 Finance Theory I, 9</td>
<td></td>
</tr>
<tr>
<td>15.812 Marketing Management, 9</td>
<td></td>
</tr>
<tr>
<td>15.751 Introduction to Operations Management, 9; 6.041*</td>
<td></td>
</tr>
<tr>
<td>Concentration Subjects:</td>
<td></td>
</tr>
<tr>
<td>Three additional subjects as specified in one of the following concentrations: Finance, Information Technologies, Marketing Science, Operations Research</td>
<td></td>
</tr>
<tr>
<td>Departmental Program Units That Also Satisfy the GIRs</td>
<td>(60)</td>
</tr>
<tr>
<td>Unrestricted Electives</td>
<td>69–81</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 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.
Part 617-253-1510, are always available to assist all students in course selection. Staff at Sloan Educational Services, Room E52-101, to assist students in course selection. The MIT Sloan course schedule is available on bidding website, as are most class syllabi, at https://sloanbid.mit.edu/ bidding. Bidding occurs at sites. All students must participate in the MIT Sloan course bidding system. Information about sites. (Two six-unit subjects will be counted as a single elective subject.)

**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 courses at MIT Sloan, if they have taken the listed prerequisites. All students 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 course 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.

**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, and Doctor of Philosophy.

**Entrance Requirements for Graduate Study**
Applications are welcome from college graduates in all areas of concentration—the humanities, social sciences, physical sciences, and engineering—but matriculants must have completed formal subjects in calculus and in economics. 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, they may be covered by formal subjects 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. GRE scores may be used in place of GMAT scores for the MBA, MFin, and doctoral programs and for LGO applicants applying through the School of Engineering.

**Master of Business Administration**
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 program of study is two consecutive years and requires candidates to complete a core curriculum plus 144 units of H- or G-level elective subjects. Residency for four academic terms is required. Students also fulfill research and leadership requirements through activities in the mid-term Sloan Innovation Period and through elective coursework.

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 elective course. After the first term, students have a wide range of elective course choices. Students also have the option of earning a certificate in either finance or entrepreneurship and innovation by enrolling in and completing the elective requirements for that track.

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 some activity 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 courses incorporate action learning into their pedagogy and require students to complete projects within companies and organizations as a deliverable for the course. In the case of “Lab” courses this may include a 1–3 week international experience working within the host organization. Students also have the opportunity to work as paid teaching and research assistants to the Sloan faculty. During the Sloan Innovation Period students are exposed to cutting edge research and ideas from faculty and leaders in management. Outside of the classroom the MBA community is home to multiple community-related student government, and professional clubs that give students the opportunity to practice leadership through the execution of conferences, international study trips and treks, business competitions, and club-related activities. Corporate leaders are also often invited to work with students either through guest lectureships...
in classes or through interaction with one of the 65+ student organizations.

Master of Finance
Beginning in 2009, the Sloan School of Management is offering a new degree program, the Master of Finance. Designed to prepare students for careers in the financial industry, the 12-month (June–May) MFin program consists of required and elective courses, a proseminar, and an optional master’s thesis.

In addition to the traditional synergies among economics, finance, and accounting, the program exploits intellectual ties between finance and mathematics, statistics, psychology, management, computer science, and engineering. The program is appropriate for recent graduates, as well as those who have several years of work experience in the finance industry. In addition, engineers, mathematicians, physicists, computer programmers, or other high-tech professionals seeking a new career in the finance world may apply.

Required summer term coursework provides the foundation in finance 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. 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.

Applications to the MFin program are due by December 31; decisions are typically announced on March 1.

Master of Science in Management Studies
The Master of Science in Management Studies program is intended for top business school students in non-US institutions who wish to undertake advanced studies in management at MIT Sloan. Students with stellar academic and work experience who will have finished at least one year of an MBA or equivalent degree program are encouraged to apply. The program will give preference to high-performing students at MIT Sloan’s international partner schools.

Students will earn a degree from MIT Sloan and one from their home institution (upon completion of degree requirements at that institution). While at MIT Sloan, students will concentrate in an area of management and, with the help of an advisor, take courses and write a thesis on this area. Graduates of the program will acquire general business acumen as well as have detailed knowledge about a specific topic in management. They will also be able to fully utilize the resources of both MIT and their home institution and tap into the alumni networks of both schools.

The program, which runs from September to June, requires full-time residence. For more information about the Master of Science in Management Studies program, visit http://mitsloan.mit.edu/academic/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 E40-315, 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 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, Materials Science and Engineering, and Mechanical Engineering. For 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 the following (although individually constructed majors are possible):

- Accounting and Control
- Economic Sociology
- Financial Economics
- Information Technologies
- Marketing
- Operations Management
- Organization Studies
- System Dynamics
- Technological Innovation and Entrepreneurship
- 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**

MBA brochures and application information are available online at [http://mitsloan.mit.edu/mba/](http://mitsloan.mit.edu/mba/); questions may be directed to mbaadmissions@sloan.mit.edu. For doctoral information, contact the Doctoral Program Office, Room E60-236, 617-253-7188 or 617-253-8957, sloanphd@sloan.mit.edu. For Leaders for Global Operations program brochures, call 617-253-1055, lgo@mit.edu. Applications are available at [http://mitsloan.mit.edu/mba/](http://mitsloan.mit.edu/mba/).

**Master’s Degree Program for Mid-Career Executives**

**MIT Sloan Fellows Program in Innovation and Global Leadership**

The MIT Sloan Fellows Program in Innovation and Global Leadership is a highly selective degree program that brings together 100 mid-career men and women from a wide variety of for-profit and nonprofit industries, organizations, and functional areas. The program is characterized by a rigorous academic curriculum, frequent interactions with international business and government leaders, and a valuable exchange of global perspectives. The fellows work together in a team environment tackling practical issues with a spirit of intellectual adventure. After collaborating across disciplines, cultures, and backgrounds in this intense learning environment, they leave the program with the skills necessary to create change, build alliances, and drive global ventures.

In addition to the traditional 12-month, full-time program, MIT Sloan offers the flex option, designed especially for those within a one-hour radius of Boston. The flex option permits fellows to complete the program in two years, after attending the summer term full time, thus allowing them to maintain a presence in their organization.

For more information about the MIT Sloan Fellows Program in Innovation and Global Leadership and how to apply, visit the website at [http://mitsloan.mit.edu/fellows/](http://mitsloan.mit.edu/fellows/) or contact the program office, Room E52-126, 617-253-8600, fax 617-252-1200, fellows@sloan.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://web.mit.edu/cdo-program/index.html.

Faculty and Staff

David C. Schmittlein, PhD
John C Head III Dean
Robert Michael Freund, PhD
Theresa Seley Professor of Management Science
Deputy Dean
Richard M. Locke, PhD
Alvin J. Siteman (1948) Professor of Entrepreneurship
Professor of Political Science
Deputy Dean
JoAnne Yates, PhD
Sloan Distinguished Professor of Management
Deputy Dean

Faculty and Teaching Staff

Professors

Deborah Gladstein Ancona, PhD
Seley Distinguished Professor of Management
Faculty Director, MIT Leadership Center
Paul Asquith, PhD
Gordon Y Billard Professor of Finance
Arnold Irwin Barnett, PhD
George Eastman Professor of Management Science
Professor of Operations Research and Management
Ernst R. Berndt, PhD
Louis E. Seley Professor of Applied Economics
Dimitris Bertsimas, PhD
Boeing Leaders for Manufacturing Professor of Management
Codirector, Operations Research Center
Gabriel Richard Bitran, PhD
Society of Sloan Fellows Professor
Erik Brynjolfsson, PhD
The Schussel Family Fund Professor of Management Science
Codirector, MIT Center for Digital Business
John Stephen Carroll, PhD
Morris A. Adelman Professor of Management
Professor of Engineering Systems
Codirector, Lean Advancement Initiative
John Carrington Cox, PhD
Nomura Professor of Finance
Michael A. Cusumano, PhD
Sloan Management Review Professor of Management
Professor of Engineering Systems
Steven D. Eppinger, ScD
General Motors Leaders for Manufacturing Professor of Management
Professor of Engineering Systems
Roberto M. Fernández, PhD
William F. Pounds Professor of Management
Charles Harry Fine, PhD
Chrysler Leaders for Manufacturing Professor of Management
Professor of Engineering Systems
Codirector, International Motor Vehicle Program
Kristin J. Forbes, PhD
Professor of International Management
Robert S. Gibbons, PhD
Sloan Distinguished Professor of Management
Stephen C. Graves, PhD
Abraham J. Siegel Professor of Management
Mechanical Engineering
John Richard Hauser, ScD
Kirin Professor of Marketing
Bengt R. Holmstrom, PhD
Paul A. Samuelson Professor of Economics and Management
Yasheng Huang, PhD
China Program Professor of International Management
Simon H. Johnson, PhD
Ronald A. Kurtz (1954) Professor of Entrepreneurship
Paul Lewis Joskow, PhD
Elizabeth and James Killian Professor of Economics and Management
Thomas Anton Kochan, PhD
George Maverick Bunker Professor of Management
Professor of Engineering Systems
Codirector, MIT Sloan Institute for Work and Employment Research
Leonid Kogan, PhD
Nippon Telegraph and Telephone Professor of Management
S. P. Kothari, PhD
Gordon Y Billard Professor of Management
Donald Roy Lessard, PhD
Epoch Foundation Professor of International Management
Faculty Director, BP Projects Academy
John Dutton Conant Little, PhD
Institute Professor
Andrew W. Lo, PhD
Harris and Harris Group Professor
Director, Laboratory for Financial Engineering
Stuart Elliot Madnick, PhD
John Norris Maguire (1960) Professor
Professor for Engineering Systems
Codirector, PROFIT Program
Thomas Lee Magnanti, PhD
Wanda J. Orlikowski, PhD
Alfred P. Sloan Professor of Management
James Berger Orlin, PhD
E. Pennell Brooks (1917) Professor of Management
MacVicar Faculty Fellow
Paul Osterman, PhD
Nanyang Technological University Professor
Codirector, MIT Sloan Institute for Work and Employment Research
Georgia Perakis, PhD
Professor of Management

Robert Stephen Pindyck, PhD
Bank of Tokyo–Mitsubishi Ltd. Professor of Finance and Economics

Drazen Prelec, PhD
Digital Equipment Corporation Leaders for Manufacturing Professor of Management
Professor of Economics and Brain and Cognitive Sciences

Roberto Rigobón, PhD
Professor of Economics

Edward Baer Roberts, PhD
David Sarnoff Professor of Management
Chair, MIT Entrepreneurship Center

Stephen A. Ross, PhD
Franco Modigliani Professor of Financial Economics

Richard Lee Schmalensee, PhD
Howard W. Johnson Professor of Economics and Management
Director, MIT Center for Energy and Environmental Policy Research

Antoinette Schoar, PhD
Michael M. Koerner (1949) Professor of Entrepreneurship

Andreas S. Schulz, PhD
Professor of Management Science

Duncan Simester, PhD
Nanyang Technological University Professor

John David Sterman, PhD
Jay W. Forrester Professor of Computer Studies
Professor of Engineering Systems
Director, System Dynamics Group

Thomas Martin Stoker, PhD
Gordon Y Billard Professor of Management and Economics

Jared R. Curhan, PhD
Ford International Career Development Associate Professor

Joshua M. Ackerman, PhD
Assistant Professor of Marketing

Alessandro Bonatti, PhD
Assistant Professor of Applied Economics

Michael Braun, PhD
Homer A. Burnell (1928) Career Development Assistant Professor

Damon Centola, PhD
Assistant Professor of System Dynamics

Vivek Farias, PhD
J. Spencer Standing (1945) Assistant Professor of Management

Carola Frydman, PhD
Assistant Professor of Finance

Renee Richardson Gosline, PhD
Assistant Professor of Marketing

Michael Grubb, PhD
Assistant Professor of Finance

Rajkamal J. Iyer, PhD
Assistant Professor of Finance

John Eastin Van Maanen, PhD
Erwin H. Schell Professor of Management
Professor of Engineering Systems

Eric Arthur von Hippel, PhD
T. Wilson (1953) Professor of Management
Professor of Engineering Systems

Jiang Wang, PhD
Mizuho Financial Group Professor

Ross L. Watts, PhD
Erwin H. Schell Professor of Management

Roy Elmer Welsch, PhD
Professor of Statistics and Management Science
Professor of Engineering Systems
Director, Center for Computational Research in Economics and Management Science

Birger Wernerfelt, DBA
J. C. Penney Professor of Management

Ezra W. Zuckerman, PhD
Nanyang Technological University Program Chair

Pierre Azoulay, PhD
Zenon Zametos (1955) Career Development Associate Professor

Nittai Bergman, PhD
Associate Professor of Finance

Emilio Castilla, PhD
W. Maurice Young (1961) Career Development Associate Professor

Jared R. Curhan, PhD
Ford International Career Development Associate Professor

Joseph J. Doyle, PhD
Associate Professor of Finance

Jeremie Gallien, PhD
Associate Professor of Management

David Gamarnik, PhD
J. Spencer Standish (1945) Associate Professor of Management

Michelle Hanlon, PhD
Associate Professor of Accounting

Robert N. Noyce Career Development Associate Professor

Fiona Elizabeth Murray, PhD
Sarofim Family Career Development Associate Professor

Jun Pan, PhD
Associate Professor of Finance

Ray E. Reagans, PhD
Associate Professor of Management

Nelson Repenning, PhD
Associate Professor of Management

Sugata Roychowdhury, PhD
Associate Professor of Accounting

Joseph P. Weber, PhD
Associate Professor of Accounting

Associate Professors
Pierre Azoulay, PhD
Zenon Zametos (1955) Career Development Associate Professor

Nittai Bergman, PhD
Associate Professor of Finance

Emilio Castilla, PhD
W. Maurice Young (1961) Career Development Associate Professor

Jared R. Curhan, PhD
Ford International Career Development Associate Professor

Joseph J. Doyle, PhD
Associate Professor of Finance

Jeremie Gallien, PhD
Associate Professor of Management

David Gamarnik, PhD
J. Spencer Standish (1945) Associate Professor of Management

Michelle Hanlon, PhD
Associate Professor of Accounting

Robert N. Noyce Career Development Associate Professor

Fiona Elizabeth Murray, PhD
Sarofim Family Career Development Associate Professor

Jun Pan, PhD
Associate Professor of Finance

Ray E. Reagans, PhD
Associate Professor of Management

Nelson Repenning, PhD
Associate Professor of Management

Sugata Roychowdhury, PhD
Associate Professor of Accounting

Joseph P. Weber, PhD
Associate Professor of Accounting

Assistant Professors
Pierre Azoulay, PhD
Zenon Zametos (1955) Career Development Associate Professor

Nittai Bergman, PhD
Associate Professor of Finance

Emilio Castilla, PhD
W. Maurice Young (1961) Career Development Associate Professor

Jared R. Curhan, PhD
Ford International Career Development Associate Professor

Joseph J. Doyle, PhD
Associate Professor of Finance

Jeremie Gallien, PhD
Associate Professor of Management

David Gamarnik, PhD
J. Spencer Standish (1945) Associate Professor of Management

Michelle Hanlon, PhD
Associate Professor of Accounting

Robert N. Noyce Career Development Associate Professor

Fiona Elizabeth Murray, PhD
Sarofim Family Career Development Associate Professor

Jun Pan, PhD
Associate Professor of Finance

Ray E. Reagans, PhD
Associate Professor of Management

Nelson Repenning, PhD
Associate Professor of Management

Sugata Roychowdhury, PhD
Associate Professor of Accounting

Joseph P. Weber, PhD
Associate Professor of Accounting

Assistant Professors
Pierre Azoulay, PhD
Zenon Zametos (1955) Career Development Associate Professor

Nittai Bergman, PhD
Associate Professor of Finance

Emilio Castilla, PhD
W. Maurice Young (1961) Career Development Associate Professor

Jared R. Curhan, PhD
Ford International Career Development Associate Professor

Joseph J. Doyle, PhD
Associate Professor of Finance

Jeremie Gallien, PhD
Associate Professor of Management

David Gamarnik, PhD
J. Spencer Standish (1945) Associate Professor of Management

Michelle Hanlon, PhD
Associate Professor of Accounting

Robert N. Noyce Career Development Associate Professor

Fiona Elizabeth Murray, PhD
Sarofim Family Career Development Associate Professor

Jun Pan, PhD
Associate Professor of Finance

Ray E. Reagans, PhD
Associate Professor of Management

Nelson Repenning, PhD
Associate Professor of Management

Sugata Roychowdhury, PhD
Associate Professor of Accounting

Joseph P. Weber, PhD
Associate Professor of Accounting

Assistant Professors
Pierre Azoulay, PhD
Zenon Zametos (1955) Career Development Associate Professor

Nittai Bergman, PhD
Associate Professor of Finance

Emilio Castilla, PhD
W. Maurice Young (1961) Career Development Associate Professor

Jared R. Curhan, PhD
Ford International Career Development Associate Professor

Joseph J. Doyle, PhD
Associate Professor of Finance

Jeremie Gallien, PhD
Associate Professor of Management

David Gamarnik, PhD
J. Spencer Standish (1945) Associate Professor of Management

Michelle Hanlon, PhD
Associate Professor of Accounting

Robert N. Noyce Career Development Associate Professor

Fiona Elizabeth Murray, PhD
Sarofim Family Career Development Associate Professor

Jun Pan, PhD
Associate Professor of Finance

Ray E. Reagans, PhD
Associate Professor of Management

Nelson Repenning, PhD
Associate Professor of Management

Sugata Roychowdhury, PhD
Associate Professor of Accounting

Joseph P. Weber, PhD
Associate Professor of Accounting

Assistant Professors
Pierre Azoulay, PhD
Zenon Zametos (1955) Career Development Associate Professor

Nittai Bergman, PhD
Associate Professor of Finance

Emilio Castilla, PhD
W. Maurice Young (1961) Career Development Associate Professor

Jared R. Curhan, PhD
Ford International Career Development Associate Professor

Joseph J. Doyle, PhD
Associate Professor of Finance

Jeremie Gallien, PhD
Associate Professor of Management

David Gamarnik, PhD
J. Spencer Standish (1945) Associate Professor of Management

Michelle Hanlon, PhD
Associate Professor of Accounting

Robert N. Noyce Career Development Associate Professor

Fiona Elizabeth Murray, PhD
Sarofim Family Career Development Associate Professor

Jun Pan, PhD
Associate Professor of Finance

Ray E. Reagans, PhD
Associate Professor of Management

Nelson Repenning, PhD
Associate Professor of Management

Sugata Roychowdhury, PhD
Associate Professor of Accounting

Joseph P. Weber, PhD
Associate Professor of Accounting

Assistant Professors
Pierre Azoulay, PhD
Zenon Zametos (1955) Career Development Associate Professor

Nittai Bergman, PhD
Associate Professor of Finance

Emilio Castilla, PhD
W. Maurice Young (1961) Career Development Associate Professor

Jared R. Curhan, PhD
Ford International Career Development Associate Professor

Joseph J. Doyle, PhD
Associate Professor of Finance

Jeremie Gallien, PhD
Associate Professor of Management

David Gamarnik, PhD
J. Spencer Standish (1945) Associate Professor of Management

Michelle Hanlon, PhD
Associate Professor of Accounting

Robert N. Noyce Career Development Associate Professor

Fiona Elizabeth Murray, PhD
Sarofim Family Career Development Associate Professor

Jun Pan, PhD
Associate Professor of Finance

Ray E. Reagans, PhD
Associate Professor of Management

Nelson Repenning, PhD
Associate Professor of Management

Sugata Roychowdhury, PhD
Associate Professor of Accounting

Joseph P. Weber, PhD
Assistant Professor of Accounting

Assistant Professors
Pierre Azoulay, PhD
Zenon Zametos (1955) Career Development Associate Professor

Nittai Bergman, PhD
Associate Professor of Finance

Emilio Castilla, PhD
W. Maurice Young (1961) Career Development Associate Professor

Jared R. Curhan, PhD
Ford International Career Development Associate Professor

Joseph J. Doyle, PhD
Associate Professor of Finance

Jeremie Gallien, PhD
Associate Professor of Management

David Gamarnik, PhD
J. Spencer Standish (1945) Associate Professor of Management

Michelle Hanlon, PhD
Associate Professor of Accounting

Robert N. Noyce Career Development Associate Professor

Fiona Elizabeth Murray, PhD
Sarofim Family Career Development Associate Professor

Jun Pan, PhD
Associate Professor of Finance

Ray E. Reagans, PhD
Associate Professor of Management

Nelson Repenning, PhD
Associate Professor of Management

Sugata Roychowdhury, PhD
Associate Professor of Accounting

Joseph P. Weber, PhD
Assistant Professor of Accounting
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scott Joslin, PhD</td>
<td>Assistant Professor of Economics, Finance, and Accounting</td>
</tr>
<tr>
<td>Kate Kellogg, PhD</td>
<td>Class of 1954 Career Development Assistant Professor</td>
</tr>
<tr>
<td>Mozaffar Khan, PhD</td>
<td>Assistant Professor of Accounting</td>
</tr>
<tr>
<td>Denise Lewin Loyd, PhD</td>
<td>Sloan School Career Development Assistant Professor</td>
</tr>
<tr>
<td>Gustavo Manso, PhD</td>
<td>Assistant Professor of Finance</td>
</tr>
<tr>
<td>Matthew T. Marx, PhD</td>
<td>Assistant Professor of Management</td>
</tr>
<tr>
<td>Konstantin W. Milbradt, PhD</td>
<td>Assistant Professor of Finance</td>
</tr>
<tr>
<td>Mark Mortensen, PhD</td>
<td>Richard S. Leghorn (1939) Career Development Assistant Professor of Management of Technological Innovation</td>
</tr>
<tr>
<td>Jeffrey Ng, PhD</td>
<td>Assistant Professor of Accounting</td>
</tr>
<tr>
<td>Elena Obukhova, PhD</td>
<td>Assistant Professor of Finance</td>
</tr>
<tr>
<td>Fred Kayne (1960) Career Development Assistant Professor of Entrepreneurship</td>
<td></td>
</tr>
<tr>
<td>Cynthia D. Rudin, PhD</td>
<td>Assistant Professor of Statistics</td>
</tr>
<tr>
<td>Ofer Sharone, PhD</td>
<td>Assistant Professor of Management</td>
</tr>
<tr>
<td>Ewa Sletten, PhD</td>
<td>Assistant Professor of Accounting</td>
</tr>
<tr>
<td>Tavneet Suri, PhD</td>
<td>Mitsubishi Career Development Assistant Professor of International Management</td>
</tr>
<tr>
<td>Catherine Tucker, PhD</td>
<td>Douglas Drane Career Development Assistant Professor of Information Technology and Management</td>
</tr>
<tr>
<td>Adrien F. Verdelhan, PhD</td>
<td>Assistant Professor of Finance</td>
</tr>
<tr>
<td>Rodrigo Verdi, PhD</td>
<td>Sarofim Family Career Development Assistant Professor</td>
</tr>
<tr>
<td>Chris Wheat, PhD</td>
<td>Assistant Professor of Strategy</td>
</tr>
<tr>
<td>Pai-Ling Yin, PhD</td>
<td>Assistant Professor of Strategy</td>
</tr>
<tr>
<td>Juanjuan Zhang, PhD</td>
<td>Assistant Professor of Marketing</td>
</tr>
<tr>
<td>Adjunct Professor</td>
<td>Mary P. Rowe, PhD</td>
</tr>
<tr>
<td>Senior Lecturers</td>
<td>Noubar Afeyan, PhD</td>
</tr>
<tr>
<td></td>
<td>John Akula, PhD, JD</td>
</tr>
<tr>
<td></td>
<td>Seth Alexander, BS</td>
</tr>
<tr>
<td></td>
<td>President, MIT Investment Management Company</td>
</tr>
<tr>
<td></td>
<td>Howard Anderson, MBA</td>
</tr>
<tr>
<td></td>
<td>Bill Porter (1967) Professor of Entrepreneurship</td>
</tr>
<tr>
<td></td>
<td>William Aulet, MS</td>
</tr>
<tr>
<td></td>
<td>Patricia Bentley, PhD</td>
</tr>
<tr>
<td></td>
<td>Lori Breslow, PhD</td>
</tr>
<tr>
<td></td>
<td>Director, MIT Teaching and Learning Laboratory</td>
</tr>
<tr>
<td></td>
<td>Stephen F. Brown, AB</td>
</tr>
<tr>
<td></td>
<td>John F. Carrier, DS</td>
</tr>
<tr>
<td></td>
<td>Sharmila Chatterjee, PhD</td>
</tr>
<tr>
<td></td>
<td>Randy Cohen, PhD</td>
</tr>
<tr>
<td></td>
<td>Phil Cooper, MS</td>
</tr>
<tr>
<td></td>
<td>John DeToire, MS</td>
</tr>
<tr>
<td></td>
<td>A. Denny Ellerman, PhD</td>
</tr>
<tr>
<td></td>
<td>Jonathan Fleming, MPA</td>
</tr>
<tr>
<td></td>
<td>Cyrus Gibson, PhD</td>
</tr>
<tr>
<td></td>
<td>Jack Gill, PhD</td>
</tr>
<tr>
<td></td>
<td>Joseph G. Hadzima, Jr., JD</td>
</tr>
<tr>
<td></td>
<td>Leigh Hafrey, PhD</td>
</tr>
<tr>
<td></td>
<td>Neal Hartman, ABD</td>
</tr>
<tr>
<td></td>
<td>William Neal Isaacs, DPhil</td>
</tr>
<tr>
<td></td>
<td>Craig Jarchow, PhD</td>
</tr>
<tr>
<td></td>
<td>Charles F. Kane, MBA</td>
</tr>
<tr>
<td></td>
<td>Ralph Katz, PhD</td>
</tr>
<tr>
<td></td>
<td>Scott Keating, DBA</td>
</tr>
<tr>
<td></td>
<td>Christine Kelly, PhD</td>
</tr>
<tr>
<td></td>
<td>Janice Klein, PhD</td>
</tr>
<tr>
<td></td>
<td>Mark Kritzman, MBA</td>
</tr>
<tr>
<td></td>
<td>David Kurtz, MBA</td>
</tr>
<tr>
<td></td>
<td>Peter Kurzina, JD</td>
</tr>
<tr>
<td></td>
<td>Val Livada, PhD</td>
</tr>
<tr>
<td></td>
<td>Shari Loessberg, JD</td>
</tr>
<tr>
<td></td>
<td>Jeffrey Alan Meldman, PhD, JD</td>
</tr>
<tr>
<td></td>
<td>Director, Undergraduate Programs</td>
</tr>
<tr>
<td></td>
<td>Bradley Morrison, PhD</td>
</tr>
<tr>
<td>Kenneth P. Morse, MBA</td>
<td>Managing Director, MIT Entrepreneurship Center</td>
</tr>
<tr>
<td>Chris Noe, PhD</td>
<td>Sinead O’Flanagan, MS</td>
</tr>
<tr>
<td>John Parsons, PhD</td>
<td>Executive Director, MIT Center for Energy and Environmental Policy Research</td>
</tr>
<tr>
<td>John T. Preston, MBA</td>
<td>Rama Ramakrishnan, PhD</td>
</tr>
<tr>
<td>John M. Reilly, PhD</td>
<td>John Rockart, PhD</td>
</tr>
<tr>
<td>Donald Barry Rosenfield, PhD</td>
<td>Director, Leaders for Manufacturing Fellows Program</td>
</tr>
<tr>
<td>Anjali Sastry, PhD</td>
<td></td>
</tr>
<tr>
<td>Clara Otto Scharmer, PhD</td>
<td></td>
</tr>
<tr>
<td>Peter M. Senge, PhD</td>
<td></td>
</tr>
<tr>
<td>Jeffrey Shames, SM</td>
<td></td>
</tr>
<tr>
<td>Janet Shanberger, MS</td>
<td></td>
</tr>
<tr>
<td>E. Sarah Slaughter, PhD</td>
<td></td>
</tr>
<tr>
<td>Craig Stephenson, PhD</td>
<td></td>
</tr>
<tr>
<td>Henry Birdseye Weil, SM</td>
<td></td>
</tr>
<tr>
<td>Andrew Wolk, MBA</td>
<td></td>
</tr>
<tr>
<td>Lecturers</td>
<td></td>
</tr>
<tr>
<td>Kara Blackburn, MA</td>
<td></td>
</tr>
<tr>
<td>Catherine Calarco, MBA</td>
<td></td>
</tr>
<tr>
<td>Maureen Ellenberger, BSBA</td>
<td></td>
</tr>
<tr>
<td>Terence Hagney, PhD</td>
<td></td>
</tr>
<tr>
<td>Virginia Healy-Tangney, MS</td>
<td></td>
</tr>
<tr>
<td>Thomas J. Hynes III, BS</td>
<td></td>
</tr>
<tr>
<td>Richard Kivel, MS</td>
<td></td>
</tr>
<tr>
<td>Jonathon David Pelly, MBA</td>
<td></td>
</tr>
<tr>
<td>Luis Perez-Breva, PhD</td>
<td></td>
</tr>
<tr>
<td>Roberta Pittore, MBA</td>
<td></td>
</tr>
<tr>
<td>John Richardson, JD</td>
<td></td>
</tr>
<tr>
<td>Research Staff</td>
<td></td>
</tr>
<tr>
<td>Senior Research Scientist</td>
<td></td>
</tr>
<tr>
<td>Peter Weill, PhD</td>
<td>Chairman, Center for Information Systems Research</td>
</tr>
</tbody>
</table>
Principal Research Associates
Mark Klein, PhD
George Roth, PhD
Alexander Samarov, PhD

Principal Research Scientists
Jeanne Ross, PhD
Director, Center for Information Systems Research
Michael D. Siegel, PhD

Research Associates
Daniel Goldsmith, MBA
Robert Laubacher, MA

Research Scientists
Elaine Backman, BA
Nils Fonstad, PhD
Peter Gloor, PhD
Danica Mijovic-Prelec, PhD
George Westerman, PhD
Stephanie Woerner, PhD

Professors Emeriti
Thomas John Allen, Jr., PhD
Howard W. Johnson Professor of Management, Emeritus
Professor of Engineering Systems, Emeritus
Lotte Lazarsfeld Bailyn, PhD
T. Wilson Professor of Management, Emeritus
Jay W. Forrester, DEng
Germeshausen Professor of Management, Emeritus
Arnoldo Cubillos Hax, PhD
Alfred P. Sloan Professor of Management, Emeritus
Henry Donnan Jacoby, PhD
William F. Pounds Professor of Management, Emeritus
Codirector, Joint Program on the Science and Policy of Global Change
Howard Wesley Johnson, LLD
Speciality Faculty Professor of Management
Former Chairman, MIT Corporation
President, Emeritus
Gordon Mayer Kaufman, DBA
Morris A. Adelman Professor of Operations Research and Management, Emeritus

Robert Bruce McKersie, PhD
Professor of Management, Emeritus
William F. Pounds, PhD
Professor of Management, Emeritus
Paul Samuelson, PhD
Institute Professor, Emeritus
Edgar H. Schein, PhD
Sloan Fellows Professor of Management, Emeritus
Michael Stewart Scott Morton, DBA
Forrester Professor of Management, Emeritus
Abraham J. Siegel, PhD
Howard W. Johnson Professor of Management, Emeritus
Lester C. Thurow, PhD
Jerome and Dorothy Lemelson Professor of Management and Economics, Emeritus
D. Eleanor Westney, PhD
Society of Sloan Fellows Professor of International Management, Emeritus
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 300 faculty members, 1,200 graduate students, 1,000 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/.

**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 and the McGovern Institute for Brain Research, 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 Picower and McGovern 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:

- Center for Global Change Science
- Koch Institute for Integrative Cancer Research
- Laboratory for Nuclear Science
- McGovern Institute for Brain Research
- MIT Kavli Institute for Astrophysics and Space Research
- Picower Institute for Learning and Memory
- Spectroscopy Laboratory
- 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
- **SB** Biology
- **PhD** Biology
- **PhD** Biochemistry
- **PhD** Biological Oceanography (jointly offered with WHOI)
- **PhD** Biophysical Chemistry and Molecular Structure
- **PhD** Cell Biology
- **PhD** Computational and Systems Biology
- **PhD** Developmental Biology
- **PhD** Genetics
- **PhD** Immunology
- **PhD** Microbiology
- **PhD** Molecular Biology
- **PhD** Neurobiology

## Brain and Cognitive Sciences  Course 9
- **SB** Brain and Cognitive Sciences
- **PhD** Cognitive Science
- **PhD** Neuroscience

## Chemistry  Course 5
- **SB** Chemistry
- **PhD, ScD** Biological Chemistry
- **PhD, ScD** Inorganic Chemistry
- **PhD, ScD** Organic Chemistry
- **PhD, ScD** Physical Chemistry

## Computational and Systems Biology  Course CSB
- **PhD** Computational and Systems Biology (jointly offered with the School of Engineering)

## Earth, Atmospheric, and Planetary Sciences  Course 12
- **SB** Earth, Atmospheric, and Planetary Sciences
- **SM** Atmospheric Science
- **SM** Chemical Oceanography (jointly offered with WHOI)
- **SM** Climate Physics and Chemistry
- **SM** Earth and Planetary Sciences
- **SM** Marine Geology and Geophysics (jointly offered with WHOI)
- **SM** Physical Oceanography (jointly offered with WHOI)
- **PhD, ScD** Atmospheric Chemistry
- **PhD, ScD** Atmospheric Science
- **PhD, ScD** Chemical Oceanography (jointly offered with WHOI)
- **PhD, ScD** Climate Physics and Chemistry
- **PhD, ScD** Geochemistry
- **PhD, ScD** Geology
- **PhD, ScD** Geophysics
- **PhD, ScD** Marine Geology and Geophysics (jointly offered with WHOI)
- **PhD, ScD** Physical Oceanography (jointly offered with WHOI)
- **PhD, ScD** Planetary Sciences

## Mathematics  Course 18
- **SB** Mathematics
- **SB** Mathematics with Computer Science
- **PhD** Mathematics

## Microbiology  PhD
- **PhD** Microbiology

---

### 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.

---

### 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 as Recommended by the Department of 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 requirements as Course 7, and requires 180 units beyond the GIRs, except that it does not require a 30-unit laboratory subject. To satisfy the requirement

---

**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>Humantities, Arts, and Social Sciences Requirement</td>
<td>6</td>
</tr>
<tr>
<td>Restricted Electives in Science and Technology (REST) Requirement</td>
<td>8</td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>2</td>
</tr>
</tbody>
</table>

**Total GIR Subjects Required for SB Degree**

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<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**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.111 or 5.112 Principles of Chemical Science, 12</td>
<td>102</td>
</tr>
<tr>
<td>3.091 Introduction to Solid-State Chemistry, 12</td>
<td></td>
</tr>
<tr>
<td>5.12 Organic Chemistry I, 12, REST; Chemistry (GIR)</td>
<td></td>
</tr>
<tr>
<td>20.110 Thermodynamics of Biomolecular Systems, 12, REST; Calculus II (GIR), Chemistry (GIR)</td>
<td></td>
</tr>
<tr>
<td>20.111 Physical Chemistry of Biomolecular Systems, 12; Calculus II (GIR), Chemistry (GIR), Physics I (GIR); Coreq: Physics II (GIR)</td>
<td></td>
</tr>
<tr>
<td>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>7.02 or 7.020 Introduction to Experimental Biology and Communication, 18, LAB, CI-M; Biology (GIR)</td>
<td></td>
</tr>
<tr>
<td>20.109 Laboratory Fundamentals in Biological Engineering, 15, LAB, CI-M; Biology (GIR), Chemistry (GIR), permission of instructor</td>
<td></td>
</tr>
<tr>
<td>7.03 Genetics, 12, REST; Biology (GIR)</td>
<td></td>
</tr>
<tr>
<td>7.05 General Biochemistry, 12, REST; 5.12, Biology (GIR), or permission of instructor</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; 7.03, 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: 7.39 is eligible as a restricted elective; 7.19 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: 7.08i, 7.20i, 7.21, 7.22, 7.23, 7.24, 7.25, 7.26, 7.27, 7.28, 7.29i, 7.30i, 7.31, 7.33i, 7.35, 7.36, and 7.37.

One of the 30-unit project laboratory subjects in the department curriculum. Those currently offered are:

<table>
<thead>
<tr>
<th>Unit</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.13 Experimental Microbial Genetics, 30, CI-M; 7.02, 7.03, 7.05</td>
<td></td>
</tr>
<tr>
<td>7.16 Experimental Molecular Biology: Biotechnology II, 30, CI-M; 7.02, 7.03, 7.05</td>
<td></td>
</tr>
<tr>
<td>7.17 Experimental Molecular Biology: Biotechnology III, 30, CI-M; 7.02, 7.03, 7.05</td>
<td></td>
</tr>
<tr>
<td>7.18 Topics in Experimental Biology, 30, CI-M; 7.02, 7.03, 7.05</td>
<td></td>
</tr>
</tbody>
</table>

**Departmental Program Units That Also Satisfy the GIRs**

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>66</td>
</tr>
</tbody>
</table>

**Unrestricted Electives**

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>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>

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.
that students complete two Communication Intensive subjects in the major, students must take 7.02/10.702 or 20.109, and one subject from this list of approved CI-M subjects for Course 7-A: 3.014, 5.36, 5.38, 7.19, 8.13, 9.02, 9.12, 9.18, 9.63, 10.26, 10.27, 10.28, 10.29, 20.380, or 2.791J/6.021J/20.370J. Further details on the 7-A major and CI-M subjects may be obtained from the department.

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.

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:
7.02/10.702 or 20.109; 7.06, 7.08J, 7.20J, 7.21, 7.22, 7.23, 7.24, 7.25, 7.26, 7.27, 7.28, 7.29J, 7.31, 7.32J, 7.35, 7.36, and 7.37J.

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 the cellular, genetic, and molecular mechanisms responsible for the diversity of cell types that arise during development, and controlling the ways in which cells interact to produce organ systems and whole organisms. These problems are studied using vertebrates, invertebrates, and plants. Specific topics of interest include the regulation of gene expression, cell interactions, cell lineages, cell migrations, sex determination, stem cells, and cloning.

Genetics/microbiology includes genetic analyses of fundamental problems in bacteria, bacteriophage, viruses, and yeast. Areas of specific interest include protein secretion, DNA transposition, protein turnover, DNA synthesis and repair, mechanisms of genetic recombination, and electron transport in mitochondria. More complex problems under study are cellular responses to stress, plant-bacterial interactions, high resolution structure-function studies of proteins and RNAs, and the control circuits regulating gene expression. A new area of study

Computational and systems biology is a very recent area of emphasis in the department that is being co-developed 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). Computational and systems biology combines biology, engineering, and computer science in a multidisciplinary approach to the systematic analysis of complex biological phenomena. Equal emphasis is placed on computational and experimental research and on molecular and systematic views of biological function. One major role of CSBI research is to develop methods and devices that can measure, in a systematic and precise manner, the biochemical properties of large numbers of biomolecules in cells, tissues, and whole organisms. A second major CSBI goal is to build mathematical models of biological systems that link mechanistic understanding of molecular function to systems-wide knowledge of networks and interactions. Like models in mature engineering disciplines, CSBI models will capture empirical knowledge as it accumulates and will have the ability to predict experimental outcomes.

Developmental biology refers to the cellular, genetic, and molecular mechanisms responsible for the diversity of cell types that arise during development, and controlling the ways in which cells interact to produce organ systems and whole organisms. These problems are studied using vertebrates, invertebrates, and plants. Specific topics of interest include the regulation of gene expression, cell interactions, cell lineages, cell migrations, sex determination, stem cells, and cloning.
is the application of high resolution molecular techniques to problems in human genetics.

**Immunology** is the study of the genetic, cellular, and molecular mechanisms underlying the exquisite sensitivity and specificity of the immune system. The immunology group studies the chemistry of antigen-antibody and antigen-T cell receptor interactions, using the tools of molecular biology as well as classical immunological 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 track, offering access to participating faculty and neuroscience coursework across campus. The emphasis is molecular, primarily using cell-biological, developmental, and genetic approaches. Present areas of research interest include the molecular determinants of neuronal diversity and shape; of cell-adhesive, cell-inductive, and synaptic interactions; and the genetic and molecular determinants of cell-lineages, memory storage, and sensory transduction.

**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 STAFF**

**Faculty and Teaching Staff**

- Chris Kaiser, PhD
- Professor of Biology
- Department Head
- Uttam L. RajBhandary, PhD
- Lester Wolfe Professor of Molecular Biology
- Associate Department Head

**Professors**

- Angelika Amon, PhD
- Professor of Biology
- Howard Hughes Medical Institute Investigator
- Tania Baker, PhD
- E. C. Whitehead Professor of Biology
- Howard Hughes Medical Institute Investigator
- MacVicar Faculty Fellow
- David Bartel, PhD
- Professor of Biology
- Howard Hughes Medical Institute Investigator
- Member, Whitehead Institute for Biomedical Research
- Stephen Bell, PhD
- Professor of Biology
- Howard Hughes Medical Institute Investigator
- Jianzhu Chen, PhD
- Professor of Biology
- Cottrell Professor of Immunology
- Sallie W. Chisholm, PhD
- Howard Hughes Medical Institute Investigator
- McAfee Professor in Engineering
- Professor of Civil and Environmental Engineering and Biology
- Martha Constantine-Paton, PhD
- Professor of Biology
- Catherine L. Drennan, PhD
- Professor of Chemistry and Biology
- Howard Hughes Medical Institute Investigator
- Gerald R. Fink, PhD
- Member, Whitehead Institute for Biomedical Research
- Frank Gertler, PhD
- Ross Scholar Professor of Biology
- Tania Baker, PhD
- Howard Hughes Medical Institute Investigator
- Member, Broad Institute
- Professor of Biology
Alan Davis Grossman, PhD
Praecis Professor of Biology

Leonard Pershing Guarente, PhD
Novartis Professor of Biology
Associate Member, Broad Institute

Nancy Haven Hopkins, PhD
Amgen Professor of Biology

H. Robert Horvitz, PhD
David H. Koch Professor of Biology
Howard Hughes Medical Institute Investigator

David Evan Housman, PhD
Virginia and Daniel K. Ludwig Professor for Cancer Research
Associate Member, Broad Institute

Richard Olding Hynes, PhD
Virginia and Daniel K. Ludwig Professor for Cancer Research
Howard Hughes Medical Institute Investigator
Associate Member, Broad Institute

Barbara Imperiali, PhD
Class of 1922 Professor of Chemistry
Professor of Biology

Tyler Edwards Jacks, PhD
David H. Koch Professor of Biology

Howard Hughes Medical Institute Investigator
Associate Member, Broad Institute

Rudolf Jaenisch, MD
Professor of Biology
Member, Whitehead Institute for Biomedical Research

Jonathan Alan King, PhD
Professor of Biology without Tenure (Retired)

Monty Krieger, PhD
Professor of Biology

Whitehead Professor of Molecular Genetics
Associate Member, Broad Institute

Eric S. Lander, PhD
Professor of Biology
Member, Whitehead Institute for Biomedical Research
Director, Broad Institute

Douglas Lauffenburger, PhD
Whitaker Professor of Biological Engineering, Chemical Engineering, and Biology
Associate Member, Broad Institute
Head, Biological Engineering Department

Jacqueline Lees, PhD
Professor of Biology
Associate Member, Broad Institute
Associate Director, David H. Koch Center for Integrative Cancer Research

Susan L. Lindquist, PhD
Howard Hughes Medical Institute Investigator
Associate Member, Broad Institute
Member, Whitehead Institute for Biomedical Research

Harvey Franklin Lodish, PhD
Professor of Biology and Bioengineering
Associate Member, Broad Institute
Member, Whitehead Institute for Biomedical Research

Dianne K. Newman, PhD
John and Dorothy Wilson Professor of Biology and Geobiology
Howard Hughes Medical Institute Investigator

Terry L. Orr-Weaver, PhD
American Cancer Society Research Professor of Biology
Member, Whitehead Institute for Biomedical Research

David Conrad Page, MD
Professor of Biology
Howard Hughes Medical Institute Investigator
Director, Whitehead Institute for Biomedical Research

Mary Lou Pardue, PhD
Boris Magasanik Professor of Biology

Hidde Ploegh, PhD
Professor of Biology
Associate Member, Broad Institute
Member, Whitehead Institute for Biomedical Research

William G. Quinn, PhD
Professor of Neurobiology

Alexander Rich, MD
William Thompson Sedgwick Professor of Biophysics

Leona Samson, PhD
American Cancer Society Research Professor
Professor of Toxicology and Biological Engineering
Associate Member, Broad Institute
Director, Center for Environmental Health Sciences

Robert Thomas Sauer, PhD
Salvador E. Luria Professor of Biology

Phillip Allen Sharp, PhD
Institute Professor

Morgan H. Sheng, MBBS, PhD
Menicon Professor of Neuroscience
Howard Hughes Medical Institute Investigator

Anthony John Sinskey, ScD
Professor of Microbiology

Hazel Louise Sive, PhD
Professor of Biology
Member, Whitehead Institute for Biomedical Research
Associate Dean, School of Science

Frank Solomon, PhD
Professor of Biology

Lisa Amelia Steiner, MD
Professor of Immunology

JoAnne Stubbe, PhD
Novartis Professor of Chemistry
Professor of Biology

Susumu Tonegawa, PhD
Picower Professor of Biology and Neuroscience

Graham Charles Walker, PhD
American Cancer Society Research Professor

Robert Allen Weinberg, PhD
Virginia and Daniel K. Ludwig Professor for Cancer Research
Associate Member, Broad Institute
Member, Whitehead Institute for Biomedical Research

Matthew Wilson, PhD
Sherman Fairchild Professor of Neuroscience

Michael B. Yaffe, MD, PhD
Professor of Biology
Associate Member, Broad Institute
Richard Allen Young, PhD
Professor of Biology
Member, Whitehead Institute for Biomedical Research

Associate Professors
Christopher Burge, PhD
Whitehead Career Development Associate Professor of Biology
Associate Member, Broad Institute
Amy Keating, PhD
Sizer Career Development Associate Professor of Biology
Associate Member, Broad Institute
Troy Littleton, MD, PhD
Associate Professor of Biology
Elly Nedivi, PhD
Associate Professor of Neurobiology
David Sabatini, MD, PhD
Associate Professor of Biology
Howard Hughes Medical Institute Investigator
Associate Member, Broad Institute
Senior Associate Member, Whitehead Institute for Biomedical Research
Thomas Schwartz, PhD
Pfizer-Laubach Career Development Associate Professor of Biology

Assistant Professors
Laurie A. Boyer, PhD
Assistant Professor of Biology
Paul Chang, PhD
Linda and Howard Stern Career Development Assistant Professor of Biology
Iain Cheeseman, PhD
Thomas D. and Virginia W. Cabot Career Development Assistant Professor of Biology
Associate Member, Whitehead Institute for Biomedical Research
Wendy Gilbert, PhD
Assistant Professor of Biology
Michael Hemann, PhD
Latham Family Career Development Assistant Professor of Biology
Associate Member, Broad Institute

Michael Laub, PhD
Whitehead Career Development Assistant Professor of Biology
Howard Hughes Medical Institute Early Career Scientist
Carlos Lois, MD, PhD
Edward J. Poitras Assistant Professor in Human Biology and Experimental Medicine
Peter Reddien, PhD
Thomas D. and Virginia W. Cabot Career Development Assistant Professor of Biology
Howard Hughes Medical Institute Early Career Scientist
Associate Member, Broad Institute
Associate Member, Whitehead Institute for Biomedical Research
Aviv Regev, PhD
Burroughs Wellcome Fund Career Development Assistant Professor of Biology
Howard Hughes Medical Institute Early Career Scientist
Member, Broad Institute
Jeroen P. J. Saeij, PhD
Assistant Professor of Biology

Technical Instructors
Vanessa Chen, PhD
Michelle Mischke, PhD
Alice Rushforth, PhD
Diviya Sinha, PhD
Ekaterina Zagriadskaia, PhD

Instructor, Outreach Coordinator
Mandana Sassanfar, PhD

Research Staff
Research Scientists
Paolo Boccazzi, PhD
Chu Choi, PhD
Sanjay D’Souza, PhD
Robert Grant, PhD
Eyal Gur, PhD
Hyun Kang, PhD
Caroline Koehrer, PhD
Kazuhiko Kurosawa, PhD
Catherine Lee, PhD
Stuart Levine, PhD
Ky Lowenhaupt, PhD
John F. W. Quimby, PhD
Niels Ringstad, PhD

T. Sambandan, PhD
Carolyn Sevier, PhD
Laura Willis, PhD
Ayce Yesilaltay, 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
Har Gobind Khorana, PhD
Alfred P. Sloan Professor of Biology and Chemistry, 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
Professor of Medicine, Harvard Medical School
Paul Reinhard Schimmel, PhD
John D. MacArthur Professor of Biochemistry and Biophysics, Emeritus
Ethan Royal Signer, PhD
Professor of Biology, Emeritus
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.

The Bachelor of Science in Brain and Cognitive Sciences prepares students for graduate training in neurosciences, 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.

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**

**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 9.00 and two other HASS 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 9.01 in the Departmental Program)</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement (can be satisfied by a laboratory in the Departmental Program)</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Total GIr Subjects Required for SB Degree</strong></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).

<table>
<thead>
<tr>
<th>Required Subjects</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.00 Introduction to Psychology, 12, HASS</td>
<td></td>
<td>126–132</td>
</tr>
<tr>
<td>9.01 Introduction to Neuroscience, 12, REST; Physics II (GIR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.07 Statistics for Brain and Cognitive Sciences, 12; Calculus II (GIR)*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Core Subjects**

Choose six 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.

<table>
<thead>
<tr>
<th>Cognitive Science</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.34 Sensory and Social Orders, 9; 9.00*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.37I Anigrafs, 9; 9.34*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.56I Abnormal Language, 12; 24.900*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.57I Language Acquisition, 12, HASS; 24.900*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.59I Psycholinguistics, 12, HASS; 24.900* or 9.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.65 Cognitive Processes, 12, HASS; 9.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.66I Computational Cognitive Science, 12; 9.07, 18.05, 6.041, or permission of instructor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.85 Infant and Early Childhood Cognition, 12, CI-M; 9.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.900 Introduction to Linguistics, 12, HASS-D, CI-H</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Cognitive Neuroscience**

| 9.20 Cognitive Neuroscience, 12; 9.01                                            |          |       |
| 9.20 Animal Behavior, 12, HASS; 9.00*                                            |          |       |
| 9.22I A Clinical Approach to the Human Brain, 12                                  |          |       |
| 9.35 Sensation and Perception, 12; Physics II (GIR), Calculus II (GIR); or permission of instructor |          |       |
| 9.71 Functional MRI of High-Level Vision, 12, CI-M; 9.07; 9.34, 9.35, 9.65, 9.66, or permission of instructor |          |       |
| 24.900 Introduction to Linguistics, 12, HASS-D, CI-H                              |          |       |

**Neuroscience**

| 9.03 Neural Basis of Learning and Memory, 12; 9.01                              |          |       |
| 9.04 Neural Basis of Vision and Audition, 12; 9.01*                             |          |       |
| 9.05 Neural Basis of Movement, 12; 9.01*                                         |          |       |
| 9.08I Cellular Neurobiology, 12; 7.05                                           |          |       |
| 9.14 Brain Structure and Its Origins, 12; 9.01                                  |          |       |
| 9.15 Biochemistry and Pharmacology of Synaptic Transmission, 12; 9.01, 7.05, or permission of instructor |          |       |
| 9.18 Developmental Neurobiology, 12, CI-M; 9.01, 7.03, 7.05, or permission of instructor |          |       |
| 9.24I Diseases of the Nervous System, 12; 9.01                                  |          |       |
| 9.29I Introduction to Computational Neuroscience, 12; 18.03, Physics II (GIR); or permission of instructor |          |       |
| 9.31 Neurophysiology of Memory, 12; 9.01                                        |          |       |

**Laboratory**

One of the following is required:

| 9.02 Systems Neuroscience Laboratory, 12, LAB, CI-M; 9.01                        |          |       |
| 9.12 Experimental Molecular Neurobiology, 12, LAB, CI-M; 9.01, Biology (GIR)    |          |       |
| 9.61 Laboratory in Higher-Level Cognition, 12, LAB, CI-M; 9.07; 9.35, 9.59, 9.66, 9.65, 9.85, or permission of instructor |          |       |
| 9.63 Laboratory in Visual Cognition, 12, LAB, CI-M; 9.07; 9.06, 0.91, or permission of instructor |          |       |

**plus one of the following:**

| 9.01J Undergraduate Research, 12                                              |          |       |
| 9.02 Brain Laboratory, 12, LAB, CI-M; 9.01                                   |          |       |
| 9.12 Experimental Molecular Neurobiology, 12, LAB, CI-M; 9.01, Biology (GIR) |          |       |
| 9.41 Topics in Neuroscience and Cognitive Science, 18, CI-M; 9.0URG           |          |       |

---

**Minor in Psychology**

The field of psychology is represented at MIT by an interdisciplinary Program in Psychology in the School of Humanities, Arts, and Social Sciences. 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. It administers a HASS Concentration and Minor in Psychology. For information about the concentration or other aspects of the program, contact the BCS Undergraduate Office, Room 46-2005, 617-253-0482. A detailed description of the Minor in Psychology is available under Interdisciplinary Undergraduate Programs and Minors in Part 3.

For a general description of minors, see Undergraduate Education in Part 1.

**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 five 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 given in June of the second year.

All students start with a first-semester intensive core subject that provides an introduction to brain and behavioral studies from the viewpoint of systems neuroscience. In the spring term, students may choose between two core subjects, one covering cellular/molecular neuroscience and one 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.

Assistants 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 46-2005, 617-253-7403, or visit http://web.mit.edu/bcs/.

Faculty and Teaching Staff

Mriganka Sur, PhD
Howard Hughes Medical Institute Investigator
Professor of Neuroscience

Paul E. Newton Professor of Neuroscience
Associate Member, Broad Institute
Department Head

Matthew Wilson, PhD
Sherman Fairchild Professor of Neurobiology
Associate Head

Professors

Edward H. Adelson, PhD
John and Dorothy Wilson Professor of Vision Science

Mark Bear, PhD
Picower Professor of Neuroscience
Howard Hughes Medical Institute Investigator
Robert Cregar Berwick, PhD
Professor of Computational Linguistics
Emilio Bizzi, MD
Institute Professor

Emery N. Brown, MD, PhD
Professor of Computational Neuroscience and Health Sciences and Technology

Stephan Lewis Chorover, PhD
Professor of Psychology

Martha Constantine-Paton, PhD
Professor of Biology

Suzanne Corkin, PhD
Professor of Behavioral Neuroscience

Robert Desimone, PhD
Doris and Don Berkey Professor of Neuroscience
Director, McGovern Institute for Brain Research

Michale Fee
Professor of Neuroscience

John D. E. Gabrieli, PhD
Grover Hermann Professor of Health Sciences and Technology and Cognitive Neuroscience
Director, Martinos Imaging Center at the McGovern Institute for Brain Research
Codirector, Clinical Research Center

Edward A. F. Gibson, PhD
Professor of Cognitive Sciences

Ann Martin Graybiel, PhD
Institute Professor

Alan Hein, PhD
Professor of Experimental Psychology

Susan Hockfield, PhD
Professor of Neuroscience
President, MIT

Neville Hogan, PhD
Professor of Mechanical Engineering

Nancy G. Kanwisher, PhD
Ellen Swallows Richards Professor of Cognitive Neuroscience
MacVicar Faculty Fellow

Earl K. Miller, PhD
Picower Professor of Visual Neuroscience
Associate Director, Picower Institute for Learning and Memory

Tomaso Armando Poggio, PhD
Eugene McDermott Professor in the Brain Sciences and Human Behavior
Director, Center for Biological and Computational Learning

Mary Crawford Potter, PhD
Professor of Psychology

Drazen Prelec, PhD
Digital Equipment Corporation Leaders for Manufacturing Professor of Management
Professor of Economics and Brain and Cognitive Sciences

William G. Quinn, PhD
Professor of Neurobiology

Whitman Albin Richards, PhD
Professor of Cognitive Sciences

Peter Harkai Schiller, PhD
Dorothy W. Poitras Professor in Medical Engineering and Medical Physics

Gerald Edward Schneider, PhD
Professor of Neuroscience

H. Sebastian Seung, PhD
Professor of Computational Neuroscience and Physics
Howard Hughes Medical Institute Investigator

Howard Hughes Medical Institute Investigator

Morgan Hwa-Tze Sheng, MBBS, PhD
Menicon Professor of Neurobiology

Howard Hughes Medical Institute Investigator

Jean-Jacques Slotine, PhD
Professor of Mechanical Engineering and Information Sciences
Director, Nonlinear Systems Laboratory

Susumu Tonegawa, PhD
Picower Professor of Biology and Neuroscience
Howard Hughes Medical Institute Investigator

Li-Huei Tsai, PhD
Picower Professor of Neuroscience
Howard Hughes Medical Institute Investigator

Associate Member, Broad Institute
Director, Picower Institute for Learning and Memory

Kenneth N. Wexler, PhD
Professor of Psychology and Linguistics

Richard Jay Wurtman, MD
Cecil H. Green Distinguished Professor of Neuropharmacology

Associate Professors

James DiCarlo, MD, PhD
Associate Professor of Neuroscience

Alan Jasanoff, PhD
Norman C. Rasmussen Career Development Associate Professor of Nuclear Science and Engineering and Biological Engineering

J. Troy Littleton, MD, PhD
Associate Professor of Biology

Christopher Moore, PhD
Mitsui Career Development Associate Professor of Neuroscience

Elly Nedivi, PhD
Associate Professor of Neurobiology

Aude Oliva, PhD
Associate Professor of Cognitive Science

Pawan Sinha, PhD
Associate Professor of Computational Neuroscience

Joshua Tenenbaum, PhD
Associate Professor of Cognitive Science and Computation

Assistant Professors

Edward S. Boyden, PhD
Benesse Career Development Assistant Professor of Biomedical Engineering

Ki Ann Goosens, PhD
Assistant Professor of Neuroscience

Yingxi Lin, PhD
Assistant Professor of Neuroscience

Carlos Lois, MD, PhD
Assistant Professor of Neuroscience

Rebecca R. Saxe, PhD
Fred and Carole Middleton Career Development Assistant Professor of Cognitive Neuroscience

Laura Schulz, PhD
Assistant Professor of Cognitive Science

Weifeng Xu, PhD
Assistant Professor of Neuroscience

Visiting Professor

Merritt Christian Brown, PhD
Senior Lecturers/Lecturers
Thomas Byrne, MD
John Growdon, MD
Timothy J. Maher, PhD

Technical Instructors
Henry Hall, SB
Carol J. Watkins, MA

Research Staff
Senior Research Scientist
Sonal Jhaveri, PhD

Principal Research Scientists
Ruth Rosenholtz, PhD
Edward Tehovnik, PhD

Research Associates/Engineers/Scientists
Narcisse Bichot, PhD
Jill Crittenden, PhD
Natalia Denissenko, PhD
Gadi Geiger, MS
Chen Chen Gong, MMus
Noah Goodman, PhD
Zhou Guan, PhD
Julius Hedden III, PhD
Arnold Heynen, PhD
Henry Hall, PhD
Carol J. Watkins, MA

Postdoctoral Associates/Fellows
Robert Ajemian, PhD
Yulia Akbergenova, PhD
Evangelos Antzoulatos
Ken-ichi Amemori, PhD
Hicham Atalilah, PhD
Daniel Baldauf, PhD
Peter Battaloria, PhD
Marina Bedny, PhD
Gabriel Belfort, PhD
Daniel Bendor, PhD
Asha Bhakar, PhD
Joseph Biedenkapp, PhD
Miguel Bosch Pita, PhD
Scott Louis Brincat, PhD
Emile Bruneau, PhD
Derek Buhl, PhD
Anthony Burgos Robles, PhD
Eric Burguïère, PhD
Timothy J. Buschman, PhD
Froylan Calderón, PhD
Eva Carlen, PhD
Leigh Carmody, PhD
Jorge Castro, PhD
Yelin Chen, PhD
Richard Cho, PhD
Vincent Cheung, PhD
Alexander Chubykin, PhD
Jasmin Cloutier, PhD
Samuel F. Cooke, PhD
Susana dos Santos Correia, PhD
Jason Cromer, PhD
Gishnu Das, PhD
Daniel Dilks, PhD
George Dragoi, PhD
Ronen Eavri, PhD
Marianna D. Eddy, PhD
Evelina Fedorenko, PhD
Paula Feinberg-Zadek, PhD
Maria Ledia Fernández Hernández, PhD
Andre Fischer, PhD
Eveline Geiser, PhD
Joanne Gibson, PhD
Jesse Goldberg, PhD
Ji Song Guan, PhD
Hiroki Hamanaka, PhD
Xue Han, PhD
Oliver Hinds, PhD
Mark Histed, PhD
Po-jang Hsieh, PhD
Ji Hu, PhD
Inbal Isaely, PhD
Elia Issa, PhD
Frank Jaelkel, PhD
Manoj Jaiswal, PhD
Beata Jarosiewicz, PhD
Micah Johnson, PhD
Ramon Jorquera, PhD
Olivier Joubert, PhD
Hae-Yoon Jung, PhD
Wolfgang Kesch, PhD
Dohoon Kim, PhD
Fabian Kloosterman, PhD
Kami Koldewyn, PhD
Dilja Krueger
Rogier Landman, PhD
Liora Las, PhD
Hysong Lee, PhD
Ji Hye Lee, PhD
Anna Leonova, PhD
Melanie Leusssis, PhD
Monica Linden, PhD
Mingna Liu, PhD
Xu Liu, PhD
Sven Loebbrich, PhD
Michael Long, PhD
Najib Majaj, PhD
Rong Mao, PhD
Yingwei Mao, PhD
Michael McEvo, PhD
Konstantinos Meletis, PhD
Tora Mitra Ganguli, PhD
Joe Moran, PhD
Yasunobu Murata, PhD
Kevin Neville, PhD
Noa Ofen, PhD
Emily Osterweil, PhD
David Page, PhD
Ling Pan, PhD
Petti Pang, PhD
Soojin Park, PhD
David Pitcher, PhD
Frida Polli, PhD
Maria Victoria Puig Velasco
Corey Puryear, PhD
Reza Rajimehr, PhD
Elizabeth Redcay, PhD
Damien Rei, PhD
Armando Miguel Remondes, PhD
Sophie Renaudeineau, PhD
Jason Ritt, PhD
Avital Rodal, PhD
Andrîl Rudenko, PhD
Nicole Rust, PhD
Ruslan Salakhutdinov, PhD
Sridevi Sarma, PhD
Virginia Savova, PhD
Joost Schulte, PhD
James Schummers, PhD
Kenjiro Seki, PhD
Katherine Sepp, PhD
Thomas Serre, PhD
Won Mok Shim, PhD
Hideki Shimazu, PhD
Markus Siegel, PhD
Karuna Singh, PhD
Kyle Smith, PhD
Sen Song, PhD
Hiroki Sugihara, PhD
Junghyup Suh, PhD
Patrick Tierney, PhD
Daniel Tropea, PhD
Carmen Varela, PhD
Tarciso Velho, PhD
Sarah Weigelt, PhD
Audra Van Wort, PhD
Gil Westmeyer, PhD
Nathan Wilson, PhD
David Wingate, PhD
Julie Yoo, PhD
Jeannie Young, PhD
Lianne Young
Hungbo Yu, PhD
Xiao-an Zhang, PhD
Ying Zhang, PhD

Visiting Scientists/Scholars
Zhe Chen, PhD
Antoine Ezzat, PhD
Federico Girosi, PhD
Maureen Holden, PhD
Albert Hung, PhD
Gabriel Kriman, PhD
Lorenzo Rosasco, PhD
Atsushi Sato, PhD

Professor Emeritus
Richard Held, PhD
Professor of Experimental Psychology, 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, 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 are carried out in association with the work of interdisciplinary laboratories and centers (see Part 3) such as the Center for Materials Science and Engineering, Francis Bitter Magnet Laboratory, Harvard-MIT Division of Health Sciences and Technology, Institute for Soldier Nanotechnologies, Lincoln Laboratory, MIT Energy Initiative, and Spectroscopy Laboratory.

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:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.03</td>
<td>Principles of Inorganic Chemistry I</td>
</tr>
<tr>
<td>5.12</td>
<td>Organic Chemistry I</td>
</tr>
<tr>
<td>5.310</td>
<td>Laboratory Chemistry</td>
</tr>
<tr>
<td>5.60</td>
<td>Thermodynamics and Kinetics</td>
</tr>
</tbody>
</table>

Two additional subjects from the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.04</td>
<td>Principles of Inorganic Chemistry II</td>
</tr>
<tr>
<td>5.07</td>
<td>Biological Chemistry I</td>
</tr>
<tr>
<td>5.08</td>
<td>Biological Chemistry II</td>
</tr>
<tr>
<td>5.13</td>
<td>Organic Chemistry II</td>
</tr>
<tr>
<td>5.36</td>
<td>Biochemistry and Organic Laboratory</td>
</tr>
<tr>
<td>5.36U*</td>
<td>Biochemistry and Organic Laboratory</td>
</tr>
<tr>
<td>5.37</td>
<td>Organic and Inorganic Laboratory</td>
</tr>
<tr>
<td>5.37U*</td>
<td>Organic and Inorganic Laboratory</td>
</tr>
<tr>
<td>5.43</td>
<td>Advanced Organic Chemistry</td>
</tr>
<tr>
<td>5.61</td>
<td>Physical Chemistry</td>
</tr>
<tr>
<td>5.62</td>
<td>Physical Chemistry</td>
</tr>
</tbody>
</table>

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 the doctoral thesis, a student learns general methods of approach and acquires training in some of the specialized techniques of research.

The areas of research in the department include organic, inorganic, physical, and biological chemistry. The thesis frequently involves

---

*Students may complete 12 units from any combination of the modules in 5.36U and 5.37U (counted as one subject).*
more than one of these fields. Some of the research activities of the department are carried out in association with the work of interdisciplinary laboratories and centers such as the Center for Materials Science and Engineering, and the Spectroscopy Laboratory, described in the section on Interdisciplinary Research and Study in Part 3. These interdisciplinary research laboratories provide stimulating interaction among the research programs of several MIT departments and give students the opportunity to become familiar with research work in disciplines other than chemistry. Detailed information on the research activities of the faculty can be found on the departmental website, http://web.mit.edu/chemistry/www/.

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.

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 requested to submit scores from the verbal and quantitative sections of the Graduate Record Examination. Scores on the advanced examinations are optional.

Bachelor of Science in Chemistry/Course 5

<table>
<thead>
<tr>
<th>General Institute Requirements (GIrs)</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Requirement (one subject can be satisfied by 5.111 or 5.112 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 (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>
<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);
- 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>Subject</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.03 Principles of Inorganic Chemistry I, 12; 5.12</td>
<td>5.07 Biological Chemistry I, 12; 5.12</td>
</tr>
<tr>
<td>5.12 Organic Chemistry I, 12, REST; Chemistry (GIR)</td>
<td>5.13 Organic Chemistry II, 12; 5.12</td>
</tr>
<tr>
<td>Module 1 Survey of Spectroscopy, 4</td>
<td>Module 2 Inorganic Synthesis and Kinetics, 4; Module 1</td>
</tr>
<tr>
<td>Module 4 Expression and Purification of Enzyme Mutants, 4; 5.07 or 7.05; Module 2 or 5.310; Module 5</td>
<td>Module 5 Kinetics of Enzyme Inhibition, 4; 5.07 or 7.05; Module 2 or 5.310; Module 4</td>
</tr>
<tr>
<td>5.37 Organic and Inorganic Laboratory, 12</td>
<td>Module 7 Introduction to Organic Synthesis, 4; 5.13, Module 6</td>
</tr>
<tr>
<td>Module 9 Dinitrogen Cleavage, 4; 5.03, Module 6, 5.61</td>
<td>5.38 Physical Chemistry Laboratory, 12, CI-M</td>
</tr>
<tr>
<td>Module 11 Time Resolved Molecular Spectroscopy, 4; 5.61, 5.07 or 7.05; Module 5</td>
<td>Module 12 Solid State NMR, 4; 5.61, 5.07 or 7.05; Module 6</td>
</tr>
<tr>
<td>5.61 Physical Chemistry, 12, REST; Physics II (GIR), Calculus II (GIR), Chemistry (GIR)</td>
<td>Restricted Electives</td>
</tr>
<tr>
<td>At least two of the following four subjects:</td>
<td>Departmental Program Units That Also Satisfy the GIrs</td>
</tr>
<tr>
<td>5.64 Principles of Inorganic Chemistry II, 12; 5.03</td>
<td>Unrestricted Electives</td>
</tr>
<tr>
<td>5.08 Biological Chemistry II, 12; 5.12; 5.07 or 7.05</td>
<td>Total Units Beyond the GIrs Required for SB Degree</td>
</tr>
<tr>
<td>5.43 Advanced Organic Chemistry, 12; 5.13</td>
<td>No subject can be counted as both 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.</td>
</tr>
</tbody>
</table>

**Notes**

1. An alternate subject is listed in the GIR description.
2. Students 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.
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 appoints a number of degree candidates as teaching assistants who are assigned either to laboratory subjects or to discussions 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.

Faculty and Teaching Staff

Faculty and Teaching Staff

Timothy M. Swager, PhD
Professor of Chemistry
Department Head

Sylvia Teresse Ceyer, PhD
John C. Sheehan Professor of Chemistry
Associate Head

Professors

Moungi G. Bawendi, PhD
Professor of Chemistry

Stephen Leffler Buchwald, PhD
Camille Dreyfus Professor of Chemistry

Christopher C. Cummins, PhD
Professor of Chemistry

Rick Lane Danheiser, PhD
Arthur C. Cope Professor of Chemistry

John Mark Deutch, PhD, ScD
Professor of Chemistry
Institute Professor

Catherine L. Drennan, PhD
Professor of Chemistry and Biology
Howard Hughes Medical Investigator

John Martin Essigmann, PhD
William and Betsy Leitch Professor of Chemistry and Toxicology

Robert Warren Field, PhD
Robert T. Haslam and Bradley Dewey Professor of Chemistry

Gregory C. Fu, PhD
Firmenich Professor of Chemistry

Robert G. Griffin, PhD
Professor of Chemistry
Director, Francis Bitter National Magnet Laboratory and the MIT-Harvard Center for Magnetic Resonance

Barbara Imperiali, PhD
Class of 1922 Professor of Chemistry
Professor of Biology
MacVicar Faculty Fellow

Timothy F. Jamison, PhD
Paul M. Cook Career Development Professor of Chemistry

Alexander M. Klibanov, PhD
Professor of Chemistry and Bioengineering

Stephen J. Lippard, PhD
Arthur Amos Noyes Professor of Chemistry

Keith Adam Nelson, PhD
Professor of Chemistry

Daniel G. Nocera, PhD
Henry Dreyfus Professor of Energy
Professor of Chemistry

Jonas C. Peters, PhD
Professor of Chemistry

Richard Royce Schrock, PhD
Frederick G. Keyes Professor of Chemistry

Robert James Silbey, PhD
Class of 1942 Professor of Chemistry

JoAnne Stubbe, PhD
Novartis Professor of Chemistry
Professor of Biology

Steven Robert Tannenbaum, ScD
Professor of Chemistry and Toxicology

Andrei Tokmakoff, PhD
Professor of Chemistry

Associate Professors

Jianshu Cao, PhD
Associate Professor of Chemistry

Mohammad Movassaghi, PhD
Firmenich Career Development Associate Professor of Chemistry

Sarah E. O’Connor, PhD
Latham Career Development Associate Professor of Chemistry

Alice Y. Ting, PhD
Pfizer-Laubach Career Development Associate Professor of Chemistry

Troy Van Voorhis, PhD
Associate Professor of Chemistry

Assistant Professor

Long Cai, PhD
Assistant Professor of Chemistry

Christian Degen, PhD
Assistant Professor of Chemistry
Elizabeth Nolan, PhD
Assistant Professor of Chemistry

Research Staff

Sponsored Research Technical Staff
Anne Gorham, BS, MS
Operations Manager

Li Li, BS
Research Specialist

Peter Mueller, PhD
Principal Research Scientist

Jeffrey Simpson, PhD
Director, Instrumentation Facility

Professors Emeriti

Robert Arnold Alberty, PhD, ScD
Professor of Chemistry, Emeritus

Klaus Biemann, PhD
Professor of Chemistry, Emeritus

Alan Davison, PhD
Professor of Chemistry, Emeritus

Carl Wesley Garland, PhD
Professor of Chemistry, Emeritus

Frederick Davis Greene II, PhD, ScD
Professor of Chemistry, Emeritus

Daniel Schaeffer Kemp, PhD
Professor of Chemistry, Emeritus

Har Gobind Khorana, PhD
Alfred P. Sloan Professor of Biology and
Chemistry, Emeritus
Senior Lecturer

Irwin Oppenheim, PhD
Professor of Chemistry, Emeritus

Dietmar Seyferth, PhD
Robert T. Haslam and Bradley Dewey Professor
of Chemistry, Emeritus

Jeffrey Irwin Steinfield, PhD
Professor of Chemistry, Emeritus

John Stewart Waugh, PhD
Institute Professor, Emeritus
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, Lincoln Laboratory, 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.

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 coursework 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 I, 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 science, 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.

Bachelor of Science in Earth, Atmospheric, and Planetary Sciences/ Course 12

<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 [can be satisfied from among 12.001, 12.002, 12.003, and 18.03 or 18.034 in the Departmental Program]</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Requirement</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total GIR Subjects Required for SB Degree</strong></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

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>Introductory Material</td>
<td>114–126</td>
</tr>
<tr>
<td>Two of the following core subjects:</td>
<td></td>
</tr>
<tr>
<td>12.001 Introduction to Geology, 12, REST (required for concentration Area 1 and Area 4 majors)</td>
<td></td>
</tr>
<tr>
<td>12.002 Physics and Chemistry of the Terrestrial Planets, 12, REST; Physics II (GIR), Calculus II (GIR) (required for concentration Area 3 majors)</td>
<td></td>
</tr>
<tr>
<td>12.003 Physics of the Atmosphere and Ocean, 12, REST; Physics I (GIR), Calculus II (GIR); (required for concentration Area 2 and Area 4 majors)</td>
<td></td>
</tr>
<tr>
<td>12.006 Nonlinear Dynamics I: Chaos, 12; Physics II (GIR), 18.03</td>
<td></td>
</tr>
<tr>
<td><strong>One of the following mathematics subjects:</strong></td>
<td></td>
</tr>
<tr>
<td>18.030 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><strong>The following research subject:</strong></td>
<td></td>
</tr>
<tr>
<td>12.TIP Thesis and Independent Study Preparation, 6 and one of the following:</td>
<td></td>
</tr>
<tr>
<td>12.IND Independent Study (at least 6 units), CI-M; 12.TIP</td>
<td></td>
</tr>
<tr>
<td>12.THU Undergraduate Thesis (at least 6 units), CI-M; 12.TIP (required for concentration Area 3 and Area 4 majors)</td>
<td></td>
</tr>
</tbody>
</table>

Student must complete one of the following four concentration areas:

AREA 1 Geoscience

12.005 Applications of Continuum Mechanics to Earth, Atmospheric, and Planetary Sciences, 12; Physics II (GIR), Calculus II (GIR), 18.03
12.108 Structure of Earth Materials, 12; Chemistry (GIR)
12.113 Structural Geology, 12; 12.001, 12.005
3.012 Fundamentals of Materials Science and Engineering, 15, REST; 18.03*
5.60 Thermodynamics and Kinetics, 12, REST; Calculus II (GIR), Chemistry (GIR)

One of the following sets of field subjects:

12.221 Field Geophysics, 6
12.216 Environmental Geophysics, 12; 18.03
12.222 Field Geophysics Analysis, 6, CI-M; 12.221
or
12.114 Field Geology I, 6; 12.108, 12.113, or permission of instructor
12.115 Field Geology II, 18, LAB, CI-M; 12.113, 12.114

AREA 2 Atmospheres, Oceans, and Climate

5.60 Thermodynamics and Kinetics, 12, REST; Calculus II (GIR), Chemistry (GIR)
8.03 Physics II, 12, REST; Physics II (GIR), Calculus II (GIR)
12.330 Fluid Dynamics, 12; 5.60*
12.333 Atmospheric and Ocean Circulations, 12; 12.003

Two of the following physics and mathematics subjects:

12.008 Classical Mechanics: A Computational Approach, 12; Physics I (GIR), 18.03, permission of instructor or
8.09 Classical Mechanics II, 12; Physics I (GIR)
Course 12
Earth, Atmospheric, and Planetary Sciences

8.04 Quantum Physics I, 12, REST; 8.03*, 18.03*
8.07 Electromagnetism II, 12; 8.03, 18.03
18.311 Principles of Applied Mathematics, 12; Calculus II (GIR), 18.03*

One of the following laboratory subjects:
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)

AREA 3 Planetary Science and Planetary Astronomy
8.03 Physics III, 12, REST; Physics II (GIR), Calculus II (GIR)
8.04 Quantum Physics I, 12, REST; 8.03*, 18.03*
8.046 Statistical Physics I, 12; 8.03, 18.03
12.008 Classical Mechanics: A Computational Approach, 12; Physics I (GIR), 18.03
12.420 Physics and Chemistry of the Solar System, 12; 8.03, 12.002, or permission of instructor

The following laboratory subject:
12.410 Observational Techniques of Optical Astronomy, 15, LAB, CI-M; 8.282*, 8.03

AREA 4 Environmental Science
12.007 Geobiology, 12
12.102 Environmental Earth Science, 12, REST
12.103 Science and Policy of Natural Hazards, 12, CI-M
12.085 Seminar in Environmental Science, 9; 12.120, 12.103; or permission of instructor

Three subjects in one focus area:
Biology focus:
1.081J/7.30J Ecology I: The Earth System, 12, REST
7.03 Genetics, 12, REST; Biology (GIR)
5.12 Organic Chemistry I, 12, REST; Chemistry (GIR)

Chemistry focus:
5.03 Principles of Inorganic Chemistry I, 12; 5.12
5.12 Organic Chemistry I, 12, REST; Chemistry (GIR)
5.60 Thermodynamics and Kinetics, 12, REST; Calculus II (GIR), Chemistry (GIR)

Earth Science focus:
12.110 Sedimentary Geology, 12; 12.001
12.165 Geomorphology, 12; 12.001, Physics I (GIR), Calculus I (GIR)*
12.214 Environmental Geophysics, 12; 18.03

12 units from the following field or laboratory subjects:
5.310 Laboratory Chemistry, 12, LAB; 5.12
12.119 Analytical Techniques for Studying Environmental and Geologic Samples, 12, LAB
12.159 Sedimentary and Surficial Geology Investigations, 12; 12.110*
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)

Departmental Program Units That Also Satisfy the GIRs

(24–36)

Restricted Electives

6–27

One or two subjects selected with the approval of the faculty advisor from among EAPS concentration area electives, mathematics, and physics (24 units in Area 1, 6-12 units in Areas 2, and 24–27 units in Area 3).


AREA 3. Choose one: 1.00 or 12.010; Choose one: 18.04, 18.05, 18.06, 18.075

AREA 4. Choose two from a focus:
—Biology: 1.086, 5.07, 5.08, 5.13, 5.43, 9.20, 10.333J, 11.002J, 11.122

Unrestricted Electives

78

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 of the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi.

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 Program 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
Maria Zuber, PhD
Earle Griswold Professor of Geophysics and Planetary Science
Department Head

Professors
Richard P. Binzel, PhD
Professor of Planetary Sciences
Samuel A. Bowring, PhD
Breene M. Kerr Professor of Geology
MacVicar Faculty Fellow
Edward Allen Boyle, PhD
Professor of Ocean Geochemistry
Burrell Clark Burchfiel, PhD
Schlumberger Professor of Geology
James Ludlow Elliot, PhD
Professor of Plantetary Astronomy and Physics
Director, George R. Wallace, Jr., Astrophysical Observatory
Kerry Andrew Emanuel, PhD
Breene M. Kerr Professor of Atmospheric Science
Dara Entekhabi, PhD
Professor of Civil and Environmental Engineering and Earth, Atmospheric, and Planetary Sciences
J. Brian Evans, PhD
Professor of Geophysics
Raffaele Ferrari, PhD
Professor of Dynamical Oceanography
Glenn Richard Flierl, PhD
Professor of Oceanography
Frederick August Frey, PhD
Professor of Geochemistry
Timothy L. Grove, PhD
Professor of Geology
Bradford H. Hager, PhD
Cecil and Ida Green Professor of Earth Sciences
Thomas A. Herring, PhD
Professor of Geophysics
Richard Siegmund Lindzen, PhD
Alfred P. Sloan Professor of Meteorology
John C. Marshall, PhD
Professor of Atmospheric and Oceanic Sciences
F. Dale Morgan, PhD
Professor of Geophysics
Associate Director, Earth Resources Laboratory
Director, Kuwait-MIT Center
Raymond Alan Plumb, PhD
Professor of Meteorology
Director, Program in Atmospheres, Oceans and Climate
Ronald George Prinn, ScD
TEPCO Professor of Atmospheric Chemistry
Director, Center for Global Change Science
Paola Malanotte Rizzoli, PhD
Professor of Physical Oceanography
Director, MIT-WHOI Joint Program
Daniel H. Rothman, PhD
Professor of Geophysics
Leigh H. Royden, PhD
Professor of Geology and Geophysics
Roger E. Summons, PhD
Professor of Geobiology
M. Nafi Toksöz, PhD
Professor of Geophysics
Director, George R. Wallace, Jr., Geophysical Observatory
Robert van der Hilst, PhD
Professor of Geophysics
Director, Earth Resources Laboratory
Jack Wisdom, PhD
Professor of Planetary Sciences
Carl Isaac Wunsch, PhD
Cecil and Ida Green Professor of Physical Oceanography

Associate Professors
Stéphane Rondenay, PhD
Associate Professor of Seismology
Sara Seager, PhD
Associate Professor of Extrasolar Planets
Sang-Heon Shim, PhD
Associate Professor of Experimental Geophysics
Benjamin P. Weiss, PhD
Victoria P. Starr Career Development Associate Professor of Planetary Sciences

Assistant Professors
Tanya Bosak, PhD
Assistant Professor of Geobiology
Linda T. Elkins-Tanton, PhD
Assistant Professor of Geological Sciences
Oliver Jagouz, PhD
Assistant Professor of Geology
Alison Malcolm, PhD
Assistant Professor of Theoretical Geophysics
Shuhei Ono, PhD
Assistant Professor of Geochemistry
Jay Taylor Perron, PhD
Assistant Professor of Geomorphology and Planetary Science

Visiting Professors
Yves Bernabé, PhD
Professor of Geophysics
Vernon F. Cormier, PhD
Professor of Geophysics
Martijn V. de Hoop, PhD
Professor of Geophysics
James Hansen, PhD
Professor of Atmospheric Dynamics
Kenneth Strepek, PhD
Professor of Civil, Environmental, and Architectural Engineering

Senior Lecturer
Lodovica Illari, PhD
Research Staff

Senior Research Scientists
William Durham, PhD
Michael Fehler, PhD
Michael Follows, PhD

Principal Research Scientists
Nilanjan Chatterjee, PhD
Patrick Heimbach, PhD
Robert W. King, Jr., PhD
Luisa T. Molina, PhD
Robert Reilinger, PhD
William Rodi, PhD

Principal Research Engineer
Christopher Hill, BS

Research Engineer
Zhenya Zhu, PhD

Research Scientists
Eduardo Andrade Lima, PhD
Daniel Burns, PhD
Executive Director, Earth Resources Laboratory
Jean-Michel Campin, PhD
Christopher Carr, PhD
Stephanie Dutkiewicz, PhD
Constantinos Evangelinos, PhD
Ming Fang, PhD
David Ferreira, PhD
Gael Forget, PhD
Helen Hill, PhD
Jin Huang, PhD
Sadi Kuleli, PhD
Simon McClusky, PhD
Michael Person, PhD
Malcolm Pringle, PhD
Jahandar Ramezani, PhD
Srinivas Ravela, PhD
Jeffery Scott, PhD
Andrei Sokolov, PhD
David E. Smith, PhD
Shan Sun, PhD
Youshun Sun, PhD
Haijian Zhang, PhD

Research Specialists
Richard Kayser, MS
Charmaine King, BS
Linda Meinke, BS
William Olszewski, PhD

Diana Spiegel, MS
Yunpeng Wang, PhD

Postdoctoral Associates
Sheekela Baker-Yeboah, PhD
Robert Buchwaldt, PhD
Laurent Carporzen, PhD
Min Chen, PhD
Yang-Sang Choi, PhD
Xiang Gao, PhD
Pierre Gouedard, PhD
Brent Grocholski, PhD
Gill-Ran Jeong, PhD
Anthony Leboissetier, PhD
Bijing Liang, PhD
Romain Meyer, PhD
Ulrich Mok, PhD
Caroline Muller, PhD
Matthew Rigby, PhD
Matthew Rioux, PhD
Noell Selin, PhD
John Taylor, PhD
Ross Tulloch, PhD
Ben Ward, PhD
Bo Yang, PhD

Postdoctoral Fellows
Larissa Back, PhD
Noah Bechor Ben Dow, PhD
Pierre Bouihol, PhD
Gang Chen, PhD
Tianrun Chen, PhD
Olivier Devauchelle, PhD
Gregory Dumond, PhD
Yolanda Echegoyen Sanz
Christian Hallmann, PhD
Nicole Keller, PhD
Aleksandar Miskovic, PhD
Oleg Poddubnov, PhD
Julio Sepulveda, PhD
Ping Wang, PhD

Research Affiliates
Arthur Cheng, PhD
Robert Cicerone, PhD
Peter Clift, PhD
Benjamin Crosby, PhD
Norman Gaut, PhD
James Hirth, PhD
Christopher Koteas, PhD
Laurent Montesi, PhD
Delaine Reiter, PhD

Joseph B. Walsh, PhD
Wenlu Zhu, PhD

Visiting Scientists
Mark Behn, PhD
Thomas Burbine, PhD
Kevin Burke, PhD
Lilliam Casillas, PhD
Jesse Dann, PhD
Alan Faller, PhD
Geoffrey Gebbie, PhD
Amanda Gelb, PhD
Levent Gulen, PhD
Sanchayan Gupta, PhD
David Harkrider, PhD
John Hayes, PhD
Peter Huybers, PhD
Mary Krasovec, PhD
Malka Machlus, PhD
Ila Pillalamarri, PhD
Pui Ponte, PhD
Michael Prange, PhD
Dick Reesman, PhD
Carolyn Rupel, PhD
Lawrence Schwartz, PhD
Alison Shaw, PhD
Steven Singletary, PhD
Dirk Smit, PhD
Margaret Thompson, PhD
Peter Tilke, PhD
Robert Zartman, PhD

Professors Emeriti
William Francis Brace, PhD
Professor of Geology, Emeritus
Charles Claude Counselman III, PhD
Professor of Planetary Sciences, Emeritus
Theodore Richard Madden, PhD
Professor of Geophysics, Emeritus
Gordon Hemenway Pettengill, PhD
Professor of Planetary Physics, Emeritus
William F. Pinson, Jr., PhD
Associate Professor of Geology, Emeritus
M. Gene Simmons, PhD
Professor of Geophysics, Emeritus
John Brejlsford Southard, PhD
Professor of Geology, Emeritus
Peter Hunter, PhD
Professor of Climate Dynamics, 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 C.L.E. 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://www-math.mit.edu/](http://www-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 mathematics-related fields as finance, physics, business, consulting, systems analysis, or actuarial science. Students’ programs are arranged through consultation with their faculty advisors. Students majoring in other disciplines are strongly encouraged to consider a double major in mathematics.

Undergraduates in mathematics are encouraged to elect an upper-level mathematics course in each of the following subjects: 18.100C, 18.104, 18.304, 18.384, 18.424, 18.434, 18.504, 18.704, 18.784, 18.821, 18.823, 18.904, or 18.994 or one from the above list and one of the following subjects: 6.073, 8.06, or 18.310C.

The Department of Mathematics offers training and gain experience in the teaching of mathematics.

Bachelor of Science in Mathematics/Course 18

---

**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 (one subject can be satisfied by 18.03 or 18.034 in the Departmental Program)</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>Requirement</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Subjects</td>
<td>12</td>
</tr>
<tr>
<td>One of the following two subjects:</td>
<td></td>
</tr>
<tr>
<td>18.03 or 18.034 Differential Equations, 12, REST; Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td>Restricted Electives</td>
<td>96</td>
</tr>
<tr>
<td>To satisfy the requirements that students take two CI-M subjects, students must take two of the following subjects: 18.100C, 18.104, 18.304, 18.384, 18.424, 18.434, 18.504, 18.704, 18.784, 18.821, 18.823, 18.904, or 18.994 or one from the above list and one of the following subjects: 6.073, 8.06, or 18.310C.</td>
<td></td>
</tr>
<tr>
<td>General Mathematics Option</td>
<td></td>
</tr>
<tr>
<td>Eight 12-unit subjects of 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.</td>
<td></td>
</tr>
<tr>
<td>Applied Mathematics Option</td>
<td></td>
</tr>
<tr>
<td>18.310 or 18.310C Principles of Applied Mathematics, 12; Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td>18.311 Principles of Applied Mathematics, 12; Calculus II (GIR), 18.03*</td>
<td></td>
</tr>
<tr>
<td>One of the following two subjects:</td>
<td></td>
</tr>
<tr>
<td>18.03* Complex Variables with Applications, 12; Calculus II (GIR), 18.03*</td>
<td></td>
</tr>
<tr>
<td>18.112 Functions of a Complex Variable, 12; 18.100, 18.06*</td>
<td></td>
</tr>
<tr>
<td>One of the following two subjects:</td>
<td></td>
</tr>
<tr>
<td>18.06 Linear Algebra, 12, REST; Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td>18.700 Linear Algebra, 12, REST; Calculus II (GIR)</td>
<td></td>
</tr>
<tr>
<td>Four additional 12-unit Course 18 subjects from the following two groups with at least one subject from each group:</td>
<td></td>
</tr>
<tr>
<td>Group I—Probability and statistics, combinatorics, computer science</td>
<td></td>
</tr>
<tr>
<td>Group II—Numerical analysis, physical mathematics, nonlinear dynamics</td>
<td></td>
</tr>
<tr>
<td>Theoretical Mathematics Option</td>
<td></td>
</tr>
<tr>
<td>18.100 Analysis I, 12; Calculus II (GIR), 18.03*</td>
<td></td>
</tr>
<tr>
<td>18.701 Algebra I, 12; 18.700*</td>
<td></td>
</tr>
<tr>
<td>18.702 Algebra II, 12; 18.701</td>
<td></td>
</tr>
<tr>
<td>18.901 Introduction to Topology, 12; 18.100*</td>
<td></td>
</tr>
<tr>
<td>One of the following subjects:</td>
<td></td>
</tr>
<tr>
<td>18.101 Analysis II, 12; 18.100, 18.06*</td>
<td></td>
</tr>
<tr>
<td>18.102 Introduction to Functional Analysis, 12; 18.100, 18.06*</td>
<td></td>
</tr>
<tr>
<td>18.103 Fourier Analysis—Theory and Applications, 12; 18.100, 18.06*</td>
<td></td>
</tr>
<tr>
<td>An undergraduate seminar from the following list: 18.104, 18.504, 18.704, 18.784, 18.904, 18.994 (12 units).</td>
<td></td>
</tr>
<tr>
<td>Two additional Course 18 subjects of essentially different content, with the first decimal digit one or higher (24 units)</td>
<td></td>
</tr>
</tbody>
</table>

**Departmental Program Units That Also Satisfy the GIRs**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restricted Electives</td>
<td>60</td>
</tr>
</tbody>
</table>
Part 1

their mathematical formulations: propagation, engineering, and computer science. Particular attention is given to the following principles and 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 (18.602 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 (18.410J) 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. Students who have taken 6.001 before the Course 6 curriculum change may use it instead of 6.01 and, similarly, students who have taken 6.170 may use it instead of 6.005.

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.
## 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><strong>Total GIR Subjects Required for SB Degree</strong></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><strong>Required Subjects</strong></td>
</tr>
<tr>
<td>18.03 or 18.034 Differential Equations, 12, REST; Calculus II (GIR)</td>
</tr>
<tr>
<td>18.06 or 18.700 Linear Algebra, 12, REST; Calculus II (GIR)</td>
</tr>
<tr>
<td>18.404 Design and Analysis of Algorithms, 12; 6.006*</td>
</tr>
<tr>
<td>6.01 Introduction to EECS I, 12, 1/2 LAB</td>
</tr>
<tr>
<td>6.006 Introduction to Algorithms, 12; 6.01, 18.062</td>
</tr>
<tr>
<td>One subject from each of the following three groups:</td>
</tr>
<tr>
<td>18.062 Mathematics for Computer Science, 12; Calculus I (GIR)</td>
</tr>
<tr>
<td>18.310 or 18.310C Principles of Applied Mathematics, 12; Calculus II (GIR)</td>
</tr>
<tr>
<td>18.400 Automata, Computability, and Complexity, 12; 18.062</td>
</tr>
<tr>
<td>18.404 Theory of Computation, 12; 18.062*</td>
</tr>
<tr>
<td>6.005 Principles of Software Development, 12; 6.01, 18.062*</td>
</tr>
<tr>
<td>6.033 Computer System Engineering, 12; 6.004</td>
</tr>
</tbody>
</table>

## Restricted Electives

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, 6.372, 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.

To satisfy the requirements that students take two CI-M subjects, students must take two of the following subjects: 18.100C, 18.104, 18.304, 18.424, 18.434, 18.504, 18.704, 18.784, 18.821, 18.823, 18.904, or 18.994 or one from the above list and one of the following subjects: 6.033, 8.06, or 18.310C.

## Department Program Units That Also Satisfy the GIRs

<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><strong>Unrestricted Electives</strong></td>
</tr>
<tr>
<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

*Alternate prerequisites and corequisites are listed in the subject description.

1 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.
For students in the pure mathematics program, the oral part of the general examination covers three areas chosen by the student in consultation with the chairperson of the Committee on Graduate Students. One of the three areas is examined in greater depth and normally becomes the field of specialization. The examiner in this area usually becomes the thesis advisor.

For students choosing the applied mathematics program, the basic objective is a proper balance of specialization and diversity. A range of subjects is required, including some in discrete and some in continuous applied mathematics. By the end of the first year of study, each student must submit a plan of study for approval by the chair of the Applied Mathematics Committee. The general oral examination in applied mathematics tests the student’s competence in the area chosen for thesis research.

Financial Support
Nearly all graduate students in mathematics are supported in full or in part by teaching assistantships, fellowships, or research assistantships. This support is renewed for students who are progressing satisfactorily, so that they are supported for a total of four years.

Inquiries
Additional information regarding academic or research programs in mathematics, admissions, or financial aid, may be obtained from Linda Okun, Graduate Mathematics Office, Room 2-233, 617-253-2689.

Faculty and Staff

**Faculty and Teaching Staff**

Michael Sipser, PhD
Professor of Applied Mathematics
Department Head

David S. Jerison, PhD
Professor of Mathematics
MacVicar Faculty Fellow
Chairman, Committee on Pure Mathematics

Michel X. Goemans, PhD
Leighton Family Professor of Applied Mathematics
Chairman, Committee on Applied Mathematics

Professors

Michael Artin, PhD
Professor of Mathematics

Denis S. Auroux, PhD
Professor of Mathematics

David J. Benney, PhD
Professor of Applied Mathematics

Bonnie A. Berger, PhD
Professor of Applied Mathematics

Roman Bezrukovnikov, PhD
Professor of Mathematics

John W. Bush, PhD
Professor of Applied Mathematics

Hung Cheng, PhD
Professor of Applied Mathematics

Tobias H. Colding, PhD
Professor of Mathematics

Richard Mansfield Dudley, PhD
Professor of Mathematics

Alan Edelman, PhD
Professor of Applied Mathematics

Pavel I. Etingof, PhD
Professor of Mathematics

Daniel Z. Freedman, PhD
Professor of Applied Mathematics

Victor William Guillemin, PhD
Professor of Mathematics

Sigurdur Helgason, PhD
Professor of Mathematics

Victor Kac, PhD
Professor of Mathematics

Steven Kleiman, PhD
Professor of Mathematics

Daniel J. Kleitman, PhD
Professor of Applied Mathematics

F. Thomson Leighton, PhD
Professor of Applied Mathematics

George Lusztig, PhD
Abdun-Nur Professor of Mathematics

Arthur Paul Mattuck, PhD
Professor of Mathematics

James McKernan, PhD
Norbert Weiner Professor of Mathematics

Richard Burt Melrose, PhD
Simons Professor of Mathematics

Haynes R. Miller, PhD
Professor of Mathematics

MacVicar Faculty Fellow

Tomasz S. Mrowka, PhD
Simons Professor of Mathematics

Bjorn Poonen, PhD
Shannon 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
Moors Professor of Applied Mathematics

Isadore Manuel Singer, PhD
Professor of Mathematics

Institute Professor

Gigliola Staffilani, PhD
Abby Rockefeller Mauze Professor of Mathematics

Richard P. Stanley, PhD
Levinson Professor of Applied Mathematics

W. Gilbert Strang, PhD
Professor of Mathematics

Daniel W. Stroock, PhD
Professor of Mathematics

Alar Toomre, PhD
Professor of Applied Mathematics

David Alexander Vogan, Jr., PhD
Professor of Mathematics

Associate Professors

Steven G. Johnson, PhD
Associate Professor of Applied Mathematics

Kiran S. Kedlaya, PhD
Cecil and Ida B. Green Career Development Associate Professor of Mathematics

Ju-Lee Kim, PhD
Associate Professor of Mathematics
Alexander Postnikov, PhD
Associate Professor of Applied Mathematics

Assistant Professors
Mark J. Behrens, PhD
Assistant Professor of Mathematics
Benjamin B. Brubaker, PhD
Assistant Professor of Mathematics
Laurent Demanet, PhD
Assistant Professor of Applied Mathematics
Jonathan A. Kelner, PhD
KDD Career Development Assistant Professor of Applied Mathematics
Abhinav Kumar, PhD
Assistant Professor of Mathematics
Li Wang, PhD
Assistant Professor of Mathematics
Katrin Wehrheim, PhD
Rockwell International Career Development Assistant Professor of Mathematics

Visiting Professor
Todd A. Kemp, PhD
Assistant Professor of Mathematics

Senior Lecturer
John B. Lewis, PhD

CLE Moore Instructors
Sami H. Assaf, PhD
Christine Breiner, PhD
Scott Carnahan, PhD
Hans P. Christianson, PhD
Michael Eichmair, PhD
Hamid Hezari, PhD
Liat Kessler, PhD
Brett L. Kotschwar, PhD
Lionel Levine, PhD
Ivan Loseu, PhD
Grace K. Lyo, PhD
Karl E. Mahlburg, PhD
Mark McLean, PhD
Mia Minnes, PhD
Aaron Naber, PhD
Thomas Andrew Putman, PhD
Travis Schedler, PhD
Christopher Schommer-Pries, PhD
Andrew Snowden, PhD
Junecue Suh, PhD

Peter Tingley, PhD
Benjamin T. Webster, PhD
David J. Whitehouse, PhD
Chenyang Xu, PhD
Zhiwei Yun, PhD

Applied Mathematics Instructors
Olivier Bernardi, PhD
Lyubov Chumakova, PhD
Tristan Gilet, PhD
Gregg Musiker, PhD
Pedro Miguel Reis, PhD
Brendon Rhoades, PhD
Daniel See-Wai Tam, PhD

Pure Mathematics Instructor
Cameron Freer, PhD

Professors Emeriti
Herman Chernoff, PhD
Professor of Applied Mathematics, 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
Bertram Kostant, PhD
Professor of Mathematics, Emeritus
Chia-Chiao Lin, PhD
Institute Professor, Emeritus
Professor of Applied Mathematics, Emeritus
Willem V. R. Malkus, PhD
Professor of Applied 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
Harold Stark, PhD
Professor of 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, from phenomena in the small-scale domain of subatomic particles to the large-scale structure of the universe, spanning a spatial range stretching from $10^{-18}$ m to $10^{26}$ m. At each level of structural organization, active and exciting areas of investigation abound. Topics range from the basic constituents of matter (elementary particles), atomic and nuclear structure, through thermonuclear plasmas, physics at extremely low temperatures or extremely high pressures, to the evolution of stars, the large-scale structure of the universe, and the mystery of gravity.

The department has extensive facilities for experimental research, as described in the section on graduate study. Many of these are accessible to interested undergraduates in the context of the Undergraduate Research Opportunities Program. Students are encouraged to enrich their curriculum by taking advantage of this opportunity.

**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 is designed for those who are interested in other, perhaps non-traditional, 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.

**Bachelor of Science in Physics/Course 8**

<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 [can be satisfied by 8.03 or 8.04, and 18.03 or 18.034 in the Departmental Program]</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Laboratory Requirement [satisfied by 8.13 or equivalent in the Departmental Program]</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:

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).

**PLUS Departmental Program**

Subject names below are followed by credit units, and by prerequisites, if any (corequisites are indicated in italics).

**Required Subjects**

8.03 Physics III, 12; REST; Physics II (GIR), Calculus II (GIR)

18.03 Differential Equations, 12, REST; Calculus II (GIR)

or 18.034 Differential Equations, 12, REST; Calculus II (GIR)

8.04 Quantum Physics I, 12, REST; 8.03*, 18.03*

8.044 Statistical Physics I, 12; 8.03, 18.03

**Physics: Flexible Option**

One of the following subjects:

- 8.21 Physics of Energy, 12; Physics II (GIR), Calculus II (GIR)
- 8.223 Classical Mechanics II, 6; Physics I (GIR), Calculus II (GIR)

One of the following subjects:

- 8.05 Quantum Physics II, 12; 8.04
- 8.20 Introduction to Special Relativity, 9, REST; Physics I (GIR), Calculus I (GIR)
- 8.033 Relativity, 12; Physics I (GIR), Calculus II (GIR)

One of the following experimental experiences:

- 8.13 Experimental Physics I, 18, LAB, CI-M; 8.04

A laboratory subject of similar intensity in another department

- An experimental research project or senior thesis
- An experimentally oriented summer externship

**Physics: Focused Option**

8.033 Relativity, 12; Physics I (GIR), Calculus II (GIR)

8.05 Quantum Physics II, 12; 8.04

8.06 Quantum Physics III, 12, CI-M; 8.05

8.13 Experimental Physics I, 18, LAB, CI-M; 8.04

8.14 Experimental Physics II, 18, LAB; 8.05, 8.13

8.223 Classical Mechanics II, 6; Physics I (GIR), Calculus II (GIR)

8.7THU Thesis (12 units)\(^{(ii)}\)

**Restricted Electives**

At least one subject in the Department of Physics in addition to those listed above (12 units)\(^{(ii)}\)

Three subjects forming one intellectually coherent unit in some area, not necessarily physics, subject to the approval of the department (36 units)

**Physics: Focused Option**

One subject in the Department of Mathematics beyond 18.03 (12 units)

Two subjects in the Department of Physics in addition to those listed above,\(^{(ii)}\) including at least one of the following: 8.07, 8.08, and 8.09 (24 units)

**Departmental Program Units That Also Satisfy the GIRs**

24–36

**Unrestricted Electives**

48–87

---

\(^{(i)}\) Except for 8.03, 8.033, and 8.04, none of which is a general requirement.

\(^{(ii)}\) These units should be chosen from the courses offered by the Department of Physics, subject to the approval of both departments.
A physics research project—Classical Mechanics II—starts 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, 18.05 Advanced Calculus for 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 forefronts 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 II.

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 their 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.

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. In the past, many students have found an understanding of the basic concepts of physics and an appreciation of the physicist's approach to problem solving an excellent preparation for careers in business, law, medicine, or engineering. This option should be even more attractive today in light of the growing spectrum of nontraditional, technology-related career opportunities.

The option begins with the core subjects 8.01, 8.02, 8.03, 8.04, 8.04, 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 following this option must 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 in the past include astronomy, biology, computational 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.

Students can satisfy the departmental portion of the Communication Requirement by taking two of the following subjects: 8.06, 8.13, 8.225, 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.

Although students may choose this option at any time in their undergraduate career, many make this choice 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 associate department head for education.

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 Thomas Greytak.

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 any five Course 8 subjects beyond the General Institute Requirements.

Students should submit a completed Minor Application Form to Physics Academic Programs, Room 4-315. The Physics Department’s minor coordinator is Sean Robinson. For more informa-
tion 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 writing to Professor Krishna Rajagopal or to Physics Academic Programs, Room 4-315, 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 Special Problems in Graduate Physics) as a first step toward an engagement in independent research for a doctoral thesis.

Research Divisions

The Astrophysics Division of the department has a varied program of instrument development and ground-based and satellite observations across the entire electromagnetic spectrum, with principal emphasis on the radio, optical, and X-ray bands. Theoretical work emphasizes high energy phenomena, stellar evolution, galactic structure, solar oscillations, and cosmology. Other areas of study include interplanetary and astrophysical plasmas, gravitational radiation, and the cosmic microwave background. See also the listing for Haystack Observatory in the section on Interdisciplinary Research and Study in Part 3.

Research activities in the Division of Nuclei and Particles include the broad fields of nuclear reaction and heavy ion physics, intermediate-energy nuclear structure physics, and high-energy fundamental particle physics. The experimental research in these areas is based on MIT's 1 GeV Bates Linear Accelerator and on the accelerators at Brookhaven National Laboratory, the Fermi National Accelerator Laboratory in Batavia, Illinois, the Stanford Linear Accelerator, CERN (Geneva), the electron-positron collider at DESY (Hamburg, Germany), and the Gran Sasso underground laboratory at Frascati (Italy). Further information appears in the section on Interdisciplinary Research and Study in Part 3 under Laboratory for Nuclear Science.

The large and dynamic program in Condensed Matter, Atomic, and Plasma Physics provides students with a wide spectrum of research opportunities. Current topics in condensed matter include electron transport and critical phenomena in one, two, and three dimensions, mesoscopic physics, and high-temperature superconductivity. Atomic physics in the division involves ultra-high resolution laser spectroscopy, the trapping and cooling of atoms with lasers, and Bose-Einstein condensation. There are strong plasma programs in magnetically confined fusion and free electron lasers. Several faculty are applying the techniques of modern physics to current problems in medicine and biology. Extensive facilities are available on campus for the preparation and characterization of advanced materials and for work with high magnetic fields, low temperatures, and sub-micron structures. Scattering studies are being carried out at the Advanced Proton Source at Argonne National Laboratory and the NIST Center for Neutron Research in Gaithersburg, Maryland.

The chief emphasis of Nuclear and Particle Theory research at the Virgil Elings Center for Theoretical Physics is on understanding the fundamental particles of nature, as revealed by their interactions and by their decay, and on the characteristic quantum modes of motion systems composed of strongly interacting particles such as atomic nuclei. Work is also conducted on theoretical astrophysics as well as on the properties of other forms of matter. In all of this research, close contact is maintained with experimentalists, both within MIT and elsewhere.

The Virgil Elings Center for Theoretical Physics houses a fairly large group of theorists including professional staff, postdoctoral fellows, senior visitors, and graduate students engaged in research in theory. Opportunities for communication and collaboration are maximized within the center; lively interaction among the many specialists in the various areas of interest is characteristic of this MIT group and is one of the major sources of the center's strength.

Much of the research in the department is carried out as part of the work of various interdisciplinary laboratories and centers, including the
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 Plasma Science and Fusion Center. These facilities, most of which are described under Interdisciplinary Research and Study in Part 3, 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 writing to Professor Krishna Rajagopal, Room 4-315, 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
Associate Head for Education

Professors
Raymond C. Ashoori, PhD
Professor of Physics

Ulrich Justus Becker, PhD
Professor of Physics

John Winston Belcher, PhD
Class of 22 Professor of Physics
MacVicar Faculty Fellow

George Bernard Benedek, PhD
Alfred H. Caspary Professor of Physics and Biological 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

Deepo Chakrabarty, PhD
Professor of Physics
Division Head, Astrophysics

Min Chen, PhD
Professor of Physics

Janet Conrad, PhD
Professor of Physics

Bruno Coppi, PhD
Professor of Physics

Mildred Spiewak Dresselhaus, PhD
Professor of Electrical Engineering and Physics
Institute Professor

James Ludlow Elliot, PhD
Professor of Earth, Atmospheric and Planetary Sciences and Physics
Director, George R. Wallace, Jr. Astrophysical Observatory

Edward Henry Farhi, PhD
Cecil and Ida B. Green Career Development Professor of Physics
Director, Center for Theoretical Physics

Michael Stephen Feld, PhD
Professor of Physics
Director, George R. Harrison Spectroscopy Laboratory

Peter H. Fisher, PhD
Professor of Physics
Division Head, Particle and Nuclear Physics

Daniel Freedman, PhD
Professor of Mathematics and Physics

Thomas John Greytak, PhD
Lester Wolfe Professor of Physics

Alan Harvey Guth, PhD
Victor F. Weisskopf Professor of Physics
MacVicar Faculty Fellow

Jacqueline N. Hewitt, PhD
Professor of Physics
Director, MIT Kavli Institute for Astrophysics and Space Research

Erich Peter Ippen, PhD
Eliehu Thomson Professor of Electrical Engineering and Physics

Roman Wladimir Jackiw, PhD
Jerrold Zacharlas Professor of Physics

Robert Jaffe, PhD
Professor of Physics

Otto and Jane Morningstar Professor of Science

Francis Wright Davis Professor of Physics
Director, Institute of Soldier Nanotechnologies

Paul Christopher Joss, PhD
Professor of Physics

Mehran Kardar, PhD
Professor of Physics

Marc Aaron Kastner, PhD
Donner Professor of Science

Dean, School of Science

Wolfgang Ketterle, PhD
John D. MacArthur Professor of Physics
Director, MIT-Harvard Center for Ultracold Atoms
(On leave, spring)

Stanley Benedict Kowalski, PhD
Professor of Physics

Patrick A. Lee, PhD
William and Emma Rogers Professor of Physics
Division Head, Atomic, Biological, Condensed Matter and Plasma Physics
(On leave)

Leonid S. Levitov, PhD
Professor of Physics

J. David Litster, PhD
Professor of Physics

June Lorraine Matthews, PhD
Professor of Physics

Nergis Mavalvala, PhD
Cecil and Ida B. Green Professor of Physics

Richard G. Milner, PhD
Professor of Physics

Director, Laboratory for Nuclear Science

Ernest J. Moniz, PhD
Cecil and Ida B. Green Distinguished Professor of Physics
Director, Energy Studies
John William Negele, PhD  
William A. Coolidge Professor of Physics  
Miklos Porkolab, PhD  
Professor of Physics  
Director, Plasma Science and Fusion Center  
David Edward Pritchard, PhD  
Cecil and Ida B. Green Professor of Physics  
Saul Alan Rappaport, PhD  
Professor of Physics  
Robert Page Redwine, PhD  
Professor of Physics  
Director, Bates Laboratory  
Paul Schechter, PhD  
William A. M. Burden Professor of Astrophysics  
H. Sebastian Seung, PhD  
Professor of Computational Neuroscience and Physics  
Washington Taylor IV, PhD  
Professor of Physics  
Max Tegmark, PhD  
Professor of Physics  
Samuel C. C. Ting, PhD  
Thomas Dudley Cabot Professor of Physics  
Alexander van Oudenaarden, PhD  
Keck Career Development Professor of Biomedical Engineering and Physics  
(On leave, spring)  
Xiao-Gang Wen, PhD  
Cecil and Ida Green Professor of Physics  
Frank Wilczek, PhD  
Herman Feshbach Professor of Physics  
Boleslaw Wysocki, PhD  
Professor of Physics  
Richard Kumeo Yamamoto, PhD  
Professor of Physics (Fall)  
Barton Zwiebach, PhD  
Professor of Physics  
MacVicar Faculty Fellow  

**Associate Professors**  
Adam Burgasser, PhD  
Associate Professor of Physics  
(On leave)  
Isaac Chuang, PhD  
Associate Professor of Electrical and Engineering and Computer Science and Physics  
Eric Hudson, PhD  
Class of 1958 Career Development Associate Professor of Physics  
Scott Hughes, PhD  
Associate Professor of Physics  
Young Sang Lee, PhD  
Mark Hyman Jr. Career Development Associate Professor of Physics  
Hong Liu, PhD  
Associate Professor of Physics  
Leonid Mirny, PhD  
Associate Professor of Health Sciences and Technology and Physics  
Christoph M. E. Paus, PhD  
Associate Professor of Physics  
Gunther Roland, PhD  
Associate Professor of Physics  
Gabriella Sciolla, PhD  
Cecil and Ida B. Green Career Development Associate Professor of Physics  
Sara Seager, PhD  
Ellen Swallow Richards Associate Professor of Earth, Atmospheric and Planetary Sciences and Physics  
Iain W. Stewart, PhD  
Associate Professor of Physics  
Bernd Surrow, PhD  
Associate Professor of Physics  
(On leave, spring)  
Senthil Todadri, PhD  
Associate Professor of Physics  
Vladan Vuletic, PhD  
Lester Wolfe Associate Professor of Physics  
(On leave, fall)  

**Assistant Professors**  
Allan Adams, PhD  
Assistant Professor of Physics  
Jan Egedal-Pedersen, PhD  
Assistant Professor of Physics  
Enectali Figueroa-Feliciano, PhD  
Assistant Professor of Physics  
Joseph Formaggio, PhD  
Class of ’56 Career Development Assistant Professor of Physics  
(On leave, fall)  
Nuh Gedik, PhD  
Assistant Professor of Physics  
Pablo Jarillo-Herrero, PhD  
Assistant Professor of Physics  
Markus Klute, PhD  
Assistant Professor of Physics  
John McGreevy, PhD  
Assistant Professor of Physics  
(On leave, fall)  
Jocelyn Monroe, PhD  
Assistant Professor of Physics  
Steven Nahn, PhD  
Assistant Professor of Physics  
Robert Simcoe, PhD  
Assistant Professor of Physics  
Marin Soljacic, PhD  
Assistant Professor of Physics  
Joshua Winn, PhD  
Class of ’42 Career Development Assistant Professor of Physics  
Martin Zwierlein, PhD  
Assistant Professor of Physics  
(On leave, spring)  

**Senior Lecturers**  
Peter Dourmashkin, PhD  
Stephen Steadman, PhD  
George S. F. Stephans, PhD  

**Lecturer**  
David Kaiser, PhD  

**Technical Instructors**  
Andrew Neely, BS  
William Sanford, BS  
Eli Sidman, BS  
Matthew Strafuss, BS  
Regina Yopak, BS
Research Staff

Senior Research Scientists
Thomas William Donnelly, PhD
Earl S. Marmar, PhD
Frank E. Taylor, PhD
Richard J. Temkin, PhD

Professors Emeriti
Michel Baranger, PhD
Professor of 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
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
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
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, Emeritus
Daniel Kleppner, PhD
Lester Wolfe Professor of Physics, Emeritus
George Fred Koster, PhD
Professor of Physics, Emeritus
Benjamin Lax, PhD
Professor of Physics, Emeritus
Walter Hendrik Gustav Lewin, PhD
Professor of Physics, Emeritus
Earle Leonard Lomon, PhD
Professor of Physics, Emeritus
Stanislaw Olbert, PhD
Professor of Physics, Emeritus
Louis Shreve Osborne, PhD
Professor of Physics, Emeritus
Irwin Abraham Pless, PhD
Professor of Physics, Emeritus
Lawrence Rosenson, PhD
Professor of Physics, Emeritus
Malcom Woodrow Pershing Strandberg, PhD
Professor of Physics, Emeritus
Rainer Weiss, PhD
Professor of Physics, Emeritus
Peter Adalbert Wolff, PhD
Professor of Physics, Emeritus
Physics Industry Forum
James Edward Young, PhD
Professor of Physics, Emeritus
Part 3

Interdisciplinary Programs
## Undergraduate Programs and Minors

Undergraduate Programs 277
Minors 277

## Graduate Programs

Computation for Design and Optimization 284
Leaders for Global Operations 284
Operations Research 285
Polymer Science and Technology 285
System Design and Management 285
Technology and Policy 286
Computational and Systems Biology 287
Harvard-MIT Division of Health Sciences and Technology 289
Joint Program with Woods Hole Oceanographic Institution 295
Microbiology 297

## Interdisciplinary Research and Study

MIT Centers, Labs, and Programs 300
Other Affiliations 320
INTERDISCIPLINARY UNDERGRADUATE PROGRAMS AND MINORS

UNDERGRADUATE PROGRAMS 277
American Studies 277
Ancient and Medieval Studies 277
Psychology Program 277
Women’s and Gender Studies Program 277

MINORS 277
Applied International Studies 277
Astronomy 278
Biomedical Engineering 278
Energy Studies 279
Psychology 280
Public Policy 280
Women’s and Gender Studies 281
HASS Minors in Regional Studies 281
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 Christopher Capozola, Room E51-175, 617-258-6668, capozzol@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 departure within Course 21. Individual programs are to be determined in consultation with Professor William Broadhead, Room E51-175, 617-258-6668, williamb@mit.edu.

Program in Psychology
Psychology, the study of human mental life and behavior, is represented at MIT as a program in the School of Humanities, Arts, and Social 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 (details are available at the HASS office).

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.

Psychology exists as a major at MIT only as a major departure within Course 21.

For other 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 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 30 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, masculinity, 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. Women’s and Gender Studies 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 Special Programs section of the MIT Subject Listing & Schedule, http://student.mit.edu/catalog/index.cgi. A full major (known as a major departure) is available by special arrangement. Women’s and Gender Studies also offers a minor program (see below) and a concentration.

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 undergraduates for this reality by integrating international learning and experiences into their course of study. The six-subject minor is organized into three areas that address key components of international education.

The first area is 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, this part of the minor gives students the opportunity
to become competent in a foreign language and learn about the culture of a foreign country or region.

The second area is international politics, economics, and history. This area offers students a set of subjects that help them to critically understand the economic, political, cultural and historical concepts and movements that create an increasingly interconnected world. Students select two or three subjects from this area. One of these subjects focuses on a chosen geographical region of specialization.

The third area is a significant international experience. 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, or study abroad. Within this area, the minor offers students subjects that directly prepare them for these experiences before they go, and help them reflect on their work, research, or study-abroad experience after they return to campus. Students choose one or two subjects. Please keep in mind that current lists may not include new subjects.

Tier I

**Language and culture:** two or three subjects that expose students to foreign languages and/or cultures, beyond first-year language subjects. At least two subjects must focus on one country or region. Consult the minor advisor for a list of approved subjects.

Tier II

**Politics, economics, and history:** two or three subjects, one of which must focus on the geographical area chosen in Tier I. Consult the minor advisor for a list of approved subjects.

Tier III

**International experience:** one or two subjects from the following group, linked to study, research, or work experiences abroad. Other subjects than these may be substituted with the approval of the minor advisor:

- 21F.019 Communicating Across Cultures
- 17.921J/21F.099 Independent International Research Project (at least 9 units)
- 17.199J/21F.098 Working in the Global Economy

Additional information can be obtained from Serenella Sferza, minor advisor, Center for International Studies, E38-755, 617-452-2693, ssferza@mit.edu.

**Minor in Astronomy**

The Minor in Astronomy, offered jointly with the Department of Earth, Atmospheric, and Planetary Sciences, covers the observational and theoretical foundations of astronomy. The minor requires seven subjects as follows:

- Astronomy, Mathematics, and Physics
- *Required subjects: 8.03, 8.282J/12.402J, 18.03 or 18.034*
20.309 Biological Engineering II: Instrumentation and Measurement
20.310J Molecular, Cellular, and Tissue Biomechanics
20.320 Analysis of Biomolecular & Cellular Systems
20.330J Fields, Forces, and Flows in Biological Systems
20.340J Materials for Biomedical Applications
20.360J Cell and Tissue Engineering
20.361J Molecular and Engineering Aspects of Biotechnology
20.370J Quantitative Physiology: Cells and Tissues
20.371J Quantitative Physiology: Organ Transport Systems
20.390J Foundations of Computational and Systems Biology

Restricted Electives
One of the following:
20.342 Molecular Structure of Biological Materials
20.380J Biotechnology and Engineering
20.411J Cell-Matrix Mechanics
20.441J Biomaterials—Tissue Interactions
20.451J Design of Medical Devices and Implants
20.481J Fundamental Limits of Biological Measurement
3.052 Nanomechanics of Materials and Biomaterials
6.121J Bioelectronics Project Laboratory
6.555J Biomedical Signal and Image Processing
6.807 Computational Functional Genomics
9.29J Introduction to Computational Neuroscience
9.641J Introduction to Neural Networks
10.28 Biological Engineering Laboratory
10.29 Biological Engineering Projects Laboratory
16.400 Human Factors Engineering
16.423J Aerospace Biomedical and Life Support Engineering
22.01 Introduction to Ionizing Radiation
22.058 Principles of Tomographic Imaging
HST.574 Introduction to Sensorimotor Neuroengineering

Science/Engineering Elective
One additional subject from the list of Biomedical Engineering Core electives above and one subject from the following, or two additional subjects from the list of Biomedical Engineering Core electives above (no further elective is required):
20.104J Chemicals in the Environment: Toxicology and Public Health
20.109J Laboratory Fundamentals in Biological Engineering
20.201J Mechanisms of Drug Actions
20.450J Molecular and Cellular Pathophysiology
3.034J Organic and Biomaterials Chemistry
7.02 Introduction to Experimental Biology and Communication
7.03 Genetics
7.06 Cell Biology

7.20J Human Physiology
10.702 Introductory Experimental Biology and Communication

For further information, please visit the Biological Engineering website at http://web.mit.edu/be/ or contact the BE Academic Office, Room 56-651, 617-253-1712.

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: Energy Science Foundations (fundamental laws and principles that govern energy sources, conversion, and uses), Social Science Foundations of Energy (social scientific perspectives and tools that explain human behavior in the energy context), and Energy 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 Minor faculty advisors.

Core Curriculum
Energy Science Foundations
Choose one of the following:
2.005 Thermal-Fluids Engineering I
5.60 Thermodynamics and Kinetics
6.007 Electromagnetic Energy: From Motors to Lasers
8.21 Physics of Energy
12.021 Earth Science, Energy, and the Environment
12.340 Global Warming Science

Social Science Foundations of Energy
Required subject:
15.031J Energy Decisions, Markets, and Policies

Energy 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
Energy Electives

Choose 24 units from the following:

- 1.071J Global Change Science (12 units)
- 1.801J Environmental Law, Policy, and Economics: Pollution Prevention and Control (12 units)
- 2.570 Nano-to-Macro Transport Processes (12 units)
- 2.612 Marine Power and Propulsion (12 units)
- 2.627 Fundamentals of Photovoltaics (12 units)
- 4.401 Introduction to Building Technology (12 units)
- 5.92 Energy in the Local Community (12 units)
- 6.061 Introduction to Electric Power Systems (12 units)
- 6.131 Power Electronics Laboratory (12 units)
- 6.701 Introduction to Nanoelectronics (12 units)
- 10.04J A Philosophical History of Energy (12 units)
- 11.162 Politics of Energy and the Environment (12 units)
- 11.165 Infrastructure in Crisis: Energy and Security Challenges (12 units)
- 11.168 Enabling an Energy-Efficient Society (12 units)
- 11.369J Energy Policy for a Sustainable Future (12 units)
- 12.213 Alternate Energy Sources (6 units)
- 14.401 Introduction to Building Technology (12 units)
- 15.026J Global Climate Change: Economics, Science, and Policy (9 units)
- 15.366 Energy Ventures (12 units)
- 15.933 Strategic Opportunities in Energy (6 units)
- 22.033 Nuclear Systems Design Project (12 units)
- 22.06 Engineering of Nuclear Systems (12 units)
- STS.032 Energy, Environment, and Society (12 units)

Students who take more than one subject from any of the core areas may be able to count the additional coursework toward the elective requirement. Contact Amanda Graham, director, MITEI Education Office, Room E19-370K, 617-253-8995, agraham@mit.edu, or visit http://web.mit.edu/mitei/education/index.html 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. It administers the HASS Minor in Psychology.

The minor 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**

- One subject:
  - 9.00 Introduction to Psychology

**Tier II**

- 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

No more than three of the subjects used to satisfy the requirements for the major in brain and cognitive sciences may be used for the Minor in Psychology.

For a listing of available subjects in these areas, consult the HASS Office, Room 14N-410, or the BCS Undergraduate Office, Room 46-2005, 617-253-0482; for information about the Psychology Program, contact the BCS Undergraduate Office.

Minor in Public Policy

Public policy is an academic field that focuses on how government action can be best utilized to enhance the quality of life of citizens. The interdisciplinary HASS Minor in Public Policy is intended to provide a single framework for students in engineering and sciences who are interested in the role of public policy in the field of their technical expertise. Course 11 majors are not eligible for the public policy minor.

The six-subject minor is organized along three dimensions. The first dimension is a foundation built on the study of market and nonmarket 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)

- 11.002/17.301 Making Public Policy
- 14.01 Principles of Microeconomics

**Tier II**

Policy Analysis (one required subject)

- 11.003/17.303 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.
The minor advisors are Professor Andrea Campbell, Room E53-461, 617-452-2295, acampbel@mit.edu, in Political Science, and Professor Judith Layzer, Room 9-328, 617-253-5196, jlayzer@mit.edu, in Urban Studies and Planning. Students can obtain additional information from Sandra Wellford, undergraduate administrator, Room 7-346A, 617-253-9403.

**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, are seeking a fuller understanding of the ways in which gender and gender constructs have shaped human understanding of self and community. The minor program consists of six 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:

<table>
<thead>
<tr>
<th>Tier I</th>
<th>Required introductory subject:</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP.401</td>
<td>Introduction to Women’s and Gender Studies</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tier II</th>
<th>Four subjects, at least one of which is drawn from each category:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Humanities and the arts</td>
</tr>
<tr>
<td></td>
<td>Social and natural sciences</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tier III</th>
<th>One advanced seminar:</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP.412J</td>
<td>Feminist Political Thought</td>
</tr>
<tr>
<td></td>
<td>or An upper-level Women’s and Gender Studies subject as determined by the director</td>
</tr>
</tbody>
</table>

For more information, see the section on Interdisciplinary Research and Study or 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/)

**HAS Minors in Regional Studies**

Several Minors in Regional Studies are offered at MIT: African and African Diaspora Studies, East Asian Studies, European Studies, Latin American Studies, Middle Eastern Studies, and Russian Studies. These interdisciplinary programs provide MIT undergraduates with valuable opportunities to acquire knowledge of a particular country or region in conjunction with proficiency in a foreign language. This better prepares them for academic, business, and government careers in a world where regions and countries are increasingly interdependent.

Because the nature of these minors is cross-disciplinary, 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) in the following configuration: two intermediate-level language subjects (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 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 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 Education Office, Room 14N-410, 617-253-4441.

**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, historical, 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 Education Office, Room 14N-410, 617-253-4441.

**Minor in East Asian Studies**

The Minor in East Asian Studies is designed for students interested in the language, history, politics, and culture of Asia. East Asia includes the countries which share a common background in the Chinese classical tradition: present-day People’s Republic of China, Taiwan, Korea, Japan, and Vietnam; but the core offerings at MIT cover China and Japan. 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) subjects in an East Asian language (Mandarin Chinese, Japanese, Korean, or Vietnamese). Chinese and Japanese are taught at MIT.

Additional information can be obtained from the minor advisor, Professor Elizabeth Garrels, Room 14N‑314, 617‑253‑9688, or the HASS Education Office, Room 14N‑410, 617‑253‑4441.

**Minor in European Studies**

The Minor in Modern European Studies is designed for students who are seeking a fuller understanding of the forces which have shaped modern Europe. The geographical and chronological scope of the minor program has been made deliberately broad to accommodate the wide variety of student interests. Subjects range in content from the Renaissance to the present, and from the British Isles to Central Europe. A student can choose to focus on one particular country or on a broader region, with a comparative perspective. Given the breadth of offerings, the student should consult closely with his or her minor advisor in order to devise a coherent program of study.

Students are expected to demonstrate intermediate level proficiency in a modern European language other than English by taking two intermediate (Levels III and IV) subjects, but they need not concentrate their other subjects on the country associated with that language.

Additional information can be obtained from the minor advisor, Professor Jeffrey Ravel, Room E51‑179, 617‑253‑4451, ravel@mit.edu, or from the HASS Education Office, Room 14N‑410, 617‑253‑4441.

**Minor in Latin American Studies**

The Minor in Latin American Studies is designed for students interested in the languages, history, politics, and cultures of Latin America. The core offerings at MIT largely 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 people living in the United States who identify themselves as Latino.

Two intermediate (Levels III and IV) subjects, either in Spanish or Portuguese, satisfy Area I. MIT offers Levels III and IV of Spanish every semester and those wishing to study Portuguese may do so at Harvard University. All students opting for the minor are required to take 21S.084J/17.55J/21A.430J Introduction to Latin American Studies.

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 Education Office, Room 14N‑410, 617‑253‑4441.

**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. 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 Education Office, Room 14N‑410, 617‑253‑4441.

**Minor in Russian Studies**

The Russian Regional Studies Minor is intended for students seeking an interdisciplinary program of study centered on Russia and the former Soviet Union. The historical, cultural, and political importance of Russia itself, as well as the nature of MIT’s subject offerings, suggest a primary concentration on that particular country, the dominant element in the former Soviet Union. The program is, however, regional in spirit, given both the multinational and multicultural role of the Russian Republic and the likelihood that other former Soviet Republics choose to remain in political and economic association with it.

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, or from the HASS Education Office, Room 14N‑410, 617‑253‑4441.
<table>
<thead>
<tr>
<th>Interdisciplinary Graduate Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computation for Design and Optimization</td>
</tr>
<tr>
<td>Leaders for Global Operations</td>
</tr>
<tr>
<td>Operations Research</td>
</tr>
<tr>
<td>Polymer Science and Technology</td>
</tr>
<tr>
<td>System Design and Management</td>
</tr>
<tr>
<td>Technology and Policy</td>
</tr>
<tr>
<td>Computational and Systems Biology</td>
</tr>
<tr>
<td>Harvard-MIT Division of Health Sciences and Technology</td>
</tr>
<tr>
<td>Joint Program with Woods Hole Oceanographic Institution</td>
</tr>
<tr>
<td>Microbiology</td>
</tr>
</tbody>
</table>
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 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 further information about the CDO program, contact Laura Koller, Room 35-329, 617-253-3725, cdo_info@mit.edu; or visit [http://mit.edu/cdo-program/](http://mit.edu/cdo-program/).

**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 LGO program combines graduate education in engineering and management for those with two or more years of work experience who as-
plore 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 SM in management or an MBA, 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
- Materials Science and Engineering
- Mechanical Engineering

For additional information, see the program description under Engineering Systems Division or the MIT Sloan School of Management, or visit [http://lgo.mit.edu/](http://lgo.mit.edu/).

**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.


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 Gareth McKinley, Room 3-250, 617-258-0754, or visit [http://web.mit.edu/ppst/](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/](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 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. 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://tppserver.mit.edu/.
The emerging 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 a new opportunity to focus on understanding 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, math, and computer science. Graduates of the program will be uniquely prepared to develop new methods, make novel discoveries, and establish new paradigms. They will also be well-positioned to assume critical leadership roles in both academia and industry, where this new area is becoming increasingly important.

Computational and systems biology, as practiced at MIT, is organized around the “3 Ds”: description, distillation, and design. In many research programs, systematic data collection is carried out for the purpose of detailed molecular- or cellular-level description of a system. 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 ideally will increase interpretability of the models in relation to evolutionary and engineering principles such as robustness, modularity, evolvability. The resulting models may also serve to facilitate both 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 MIT 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. Thus, students in the CSB graduate program can 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, 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 Department of Biology, the Department of Electrical Engineering and Computer Science, and the Department of 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), 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 literature-based class in computational and systems biology. 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 do their thesis research. CSB students also serve as teaching assistants during one semester in the second year to further develop their communication skills and 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 coursework, 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, but at the same time to provide oversight and guidance to ensure that they receive rigorous and thorough training.

**Core Curriculum**

The core curriculum consists of three classroom subjects plus a set of three two-month 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 with 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 two-month long research rotations 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 for students in the CSB PhD program. 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 area (department). To develop breadth, at least one of the electives must be from an engineering discipline and at least one from a biology-related field. Each student will design 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 in the second 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.

Faculty and Staff
CSB Graduate Committee
Bruce Tidor, PhD
Professor of Biological Engineering and Computer Science
Chris Burge
Associate Professor of Biology
Chair of the Committee
Alan D. Grossman, PhD
Praecis Professor of Biology
Amy E. Keating, PhD
Sizer Career Development Associate Professor of Biology
Scott R. Manalis, PhD
Associate Professor of Biological and Mechanical Engineering
Joel Voldman, PhD
Associate Professor of Electrical Engineering
Forest White, PhD
Mitsui Associate Professor of Biological Engineering
Jacob K. White, PhD
Cecil H. Green Professor of Electrical Engineering
HARVARD-MIT DIVISION OF HEALTH SCIENCES AND TECHNOLOGY

Founded more than 35 years ago, 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 clinical or in industry; and they become conversant with the underlying quantitative and molecular aspects of medicine and biomedical science. Within the division, more than 400 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 or industry setting
- A focused interdisciplinary research project

HST offers eight multidisciplinary options for graduate study:

1. Biomedical Enterprise Master’s Program
2. Master of Engineering in Biomedical Engineering
3. Medical Sciences MD Program
4. Medical Engineering and Medical Physics Doctoral Program
5. Speech and Hearing Bioscience and Technology Doctoral Program
6. Biomedical Informatics Training Program
7. Clinical Investigator Training Program
8. Graduate Education in Medical Sciences Certificate Program

MASTER’S PROGRAMS

Biomedical Enterprise Program

Launched in 2002 as a collaboration with the MIT Sloan School of Management, HST’s Biomedical Enterprise Program (BEP) is designed for individuals with business experience and a strong foundation in science and engineering. BEP prepares students for leadership roles in the transfer of new technologies from concept through product development to clinical adoption in the context of existing companies or newly established ventures.

Acknowledging that medical innovations in laboratory research and clinical care benefit society only when they become commercial products and services, BEP offers a unique curriculum that leverages the strengths of HST, MIT Sloan, Harvard Medical School (HMS), and the affiliated hospitals. BEP students take preclinical and engineering courses alongside HST’s MD and PhD students, and business courses with other MIT Sloan students. They participate in unique integrative courses designed to address the specific needs of starting, growing, and managing a biomedical enterprise. These courses were developed and are taught by a team of HST and Sloan faculty, including several local entrepreneurs. Also included in the curriculum is a hands-on hospital-based clinical experience that pairs students with physician-scientists and provides insight into the hospital environment and patient care.

BEP offers two dual-degree options for individuals who need training in both management and science, and a one-year degree option for business executives who already have a graduate degree in management. The dual-degree option leads to an MBA or SM degree from MIT Sloan and an SM degree from HST. The single-degree option leads to the SM degree from HST. Further information is available at http://bep.mit.edu/ or by contacting bep@mit.edu.

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/.

Master of Health Sciences and Technology

HST offers a general master’s degree program that can be coupled to other HST degree programs, such as the MD degree described below. To accommodate a wide range of student interests, the curriculum for the Master of Health Sciences and Technology degree is determined by agreement between the student and his or her advisor, and approval by HST’s Graduate Committee. There are no specific requirements other than the Institute requirement for 66 subject units and a thesis. In each case, the Institute requirement for the master’s degree must be satisfied. Further information can be obtained from HST’s Academic Office, Room E25-518, 617-258-7084.
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 the division. 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. This option may lead to a master’s degree in health sciences and technology in addition to the MD degree.

The general requirements for a master’s degree at MIT are given under Graduate Education in Part 1. The subject requirements must be in addition to the minimum number of units required for the MD degree. Subjects may be chosen in scientific, technical, or clinical areas relevant to the student’s research area. Thesis research may be conducted at MIT, Harvard, or at Harvard-affiliated teaching hospitals. The completed thesis must be approved by the thesis supervisor and submitted to HST’s Graduate Committee. The master’s thesis simultaneously fulfills the thesis requirement for HST’s MD degree. The two degrees are not formally linked; the MD degree is not a prerequisite for the master’s degree.

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 (seven to eight students per class year) 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.

Applicants to the program should have a bachelor’s degree in physical science, biology, psychology, linguistics, communication sciences and disorders, engineering, computer science, or a related field. Superior analytical skills are strongly recommended for all applicants. Additional information may be obtained at http://web.mit.edu/shbt/ or by contacting Dr. M. Christian Brown, Massachusetts Eye and Ear Infirmary, 243 Charles Street, Boston, MA 02114, 617-573-9635, mcb@epl.meei.harvard.edu.

TRAINING PROGRAMS

In addition to the specialized training programs designed as tracks within the Medical Engineering Medical Physics Doctoral Program, described above, HST offers three training programs in specific areas.

Biomedical Informatics Program

Biomedical informatics is concerned with the cognitive, information-processing, and communication tasks of medical practice, education, and research. It includes the information sciences and technology needed to support those tasks. The field is intrinsically interdisciplinary, drawing together all traditional medical disciplines, the science and technology of computing, biostatistics, epidemiology, decision sciences, and health care policy and management. In addition to a focus on clinical practice, additional areas of emphasis are in bioinformatics, and in informatics related to health services research.

HST’s predoctoral and postdoctoral training program in biomedical informatics offers fellowships to qualified US citizens or permanent residents. Several training options are offered: the Master of Science in Biomedical Informatics from HST; the PhD in Computer Science from MIT’s Department of Electrical Engineering and Computer Science; the PhD in Health Decision Science in the Department of Health Policy and Management at the Harvard School of Public Health; and research fellowship training at biomedicinformatics laboratories in Boston-area hospitals carried out in conjunction with the HST Biomedical Informatics Master’s Program. The master’s program is available only to individuals who already have advanced training in the health sciences (e.g., a doctoral degree in medicine, dentistry, nursing, veterinary medicine, clinical psychology, or a PhD in a medical relevant field such as physiology).

The combined training program offers several opportunities for education, research, and interaction among the various training sites. Course offerings at MIT and Harvard, as well as a variety of seminars, journal clubs, and other opportunities to exchange information, provide all trainees with opportunities to learn about the work at various laboratories and affiliated insti-
institutions, as well as the broader field of biomedical and health informatics.

Predoctoral fellowship applicants must concurrently apply for admission to MIT or a Harvard doctoral degree program. For more information about the Biomedical Informatics Training Program, visit [http://www.mi-boston.org/Boston-Informatics/index.html](http://www.mi-boston.org/Boston-Informatics/index.html) or contact Dr. Lucila Ohno-Machado, Decision Systems Group, Brigham and Women’s Hospital, 75 Francis Street, Boston, MA 02115, machado@dsg.harvard.edu.

**Clinical Investigator Training Program**

The Clinical Investigator Training Program (CITP) trains postdoctoral physicians from various clinical disciplines in the techniques and processes used in patient-oriented research. Trainees develop expertise in clinical investigation while participating in an extensive educational program. The two-year program is a cooperative effort between HST, Beth Israel Deaconess Medical Center, and Pfizer, Inc. The curriculum allows trainees to develop direct experience in performing clinical investigation while, simultaneously through didactic coursework, providing a strong foundation in computational and statistical sciences, biomedical ethics, the principles of clinical pharmacology, in vitro and in vivo measurement techniques, and various aspects of the drug development process. The fellowship program consists of a primary project and core curriculum, plus an elective curriculum and a project elective. Although not required, fellows may choose to pursue a Master of Medical Sciences degree from Harvard Medical School in conjunction with CITP. The degree is awarded at the end of the two-year period upon successful completion of didactic coursework, a research project, a thesis or thesis equivalent, and a qualifying examination. CITP is open to physicians who have completed the clinical requirements for Board eligibility in their chosen specialty or subspecialty. For more information or to obtain an application, visit [http://www.bidmc.harvard.edu/citp/](http://www.bidmc.harvard.edu/citp/) or contact the CITP administrative manager, Linda Bard, Beth Israel Deaconess Medical Center, 330 Brookline Ave, GZ 811, Boston, MA 02215, lbard@bidmc.harvard.edu.

**Graduate Education in Medical Sciences Certificate Program**

The MIT Graduate Education in Medical Sciences (GEMS) Training Program is a part-time certificate program that can be taken concurrently with doctoral studies and research by students in the Schools of Engineering and Science to gain exposure to biomedical and clinical sciences, including translational medicine. This educational experience for PhD graduate students in the sciences and engineering fields addresses a national need articulated by the Howard Hughes Medical Institute: the growing gap between advances in basic biology and the translation of advances into medically relevant therapies and tools for the improvement of human health.

The GEMS training program aims to integrate medical knowledge into graduate education at MIT by training a select group of PhD students to bridge the widening chasm between concept and functional execution with a supplementary curriculum that entails: (1) a human pathology course, including molecular and cellular mechanisms of disease, (2) a medical pathophysiology course, a kaleidoscope of HST’s pathophysiology curriculum, (3) a student-individualized clinical experience, working with experienced mentors who move seamlessly between clinical medicine and basic biological research, (4) a seminar showcasing examples of translation, and (5) HST’s Graduate Seminar—attended by all HST PhD candidates—focusing on professional skills needed to succeed in interdisciplinary research (ethics, responsible conduct of research, communication, etc.). GEMS participants will gain an understanding of the elements of translation, appreciate the science and art of medicine in a way that cannot be conveyed by textbooks, and develop relationships with students and faculty in the broad biomedical community.

**Inquiries**

Additional information on degree programs, admissions, and financial aid can be obtained from HST’s Academic Office, Room E25-518, 617-258-7084.

**Faculty and Staff**

**Faculty and Teaching Staff**

Ram Sasisekharan, PhD
Edward Hood Taplin Professor of Health Sciences and Technology and Biological Engineering, MIT
Director

David E. Cohen, MD, PhD
Associate Professor of Medicine and Health Sciences and Technology, HMS
Physician and Director of Hepatology, BWH, HMS
Director

**Professors (Primary Appointment at MIT)**

Sangeeta N. Bhatia, MD, PhD
Professor of Health Sciences and Technology and of Electrical Engineering and Computer Science

Howard Hughes Medical Investigator
Associate Member, Broad Institute

George B. Benedek, PhD
Alfred E. Caspary Professor of Physics and Biological Physics and Health Sciences and Technology

Louis D. Braidia, PhD

Henry Ellis Warren Professor of Electrical Engineering and Health Sciences and Technology

Emery N. Brown, MD, PhD
Professor of Health Sciences and Technology and of Computational Neuroscience

Richard J. Cohen, MD, PhD
Whitaker Professor in Biomedical Engineering

Ernest G. Cravalho, PhD
Professor of Mechanical Engineering and Health Sciences and Technology

Elazer R. Edelman, MD, PhD
Thomas D. and Virginia W. Cabot Professor of Health Sciences and Technology

Dennis M. Freeman, PhD
Professor of Electrical Engineering

John D. E. Gabrieli, PhD
Grover Hermann Professor of Health Sciences and Technology
Professor of Brain and Cognitive Sciences

John D. E. Gabrieli, PhD
Grover Hermann Professor of Health Sciences and Technology
Professor of Brain and Cognitive Sciences
Lee Gehrke, PhD
Hermann von Helmholtz Professor of Health Sciences and Technology, MIT, HMS
Professor of Microbiology and Molecular Genetics, HMS

Martha L. Gray, PhD
J. W. Kieckhefer Professor of Medical and Electrical Engineering

David E. Housman, PhD
Ludwig Professor of Biology

Robert S. Langer Jr., ScD
Kenneth J. Germeshausen Professor of Chemical and Biomedical Engineering and Health Sciences and Technology
Institute Professor

Roger G. Mark, MD, PhD
Distinguished Professor in Health Sciences and Technology and Electrical Engineering and Computer Science

Peter Szolovits, PhD
Professor of Computer Science and Engineering and Health Sciences and Technology

Richard J. Wurtman, MD
Cecil H. Green Distinguished Professor of Neuropharmacology and Health Sciences and Technology

Laurence R. Young, ScD
Apollo Program Professor of Astronautics and Health Sciences and Technology

Professors (Primary Appointment at HMS and Affiliated Hospitals)

R. Rox Anderson, MD
Professor of Dermatology and Health Sciences and Technology, MGH

Joseph V. Bonventre, MD, PhD
Robert H. Ebert Professor of Medicine and Health Sciences and Technology, BWH

Thomas N. Byrne, MD
Clinical Professor of Neurology and Health Sciences and Technology, MGH

Lee Gehrke, PhD
Hermann von Helmholtz Professor of Health Sciences and Technology, MIT, HMS
Professor of Microbiology and Molecular Genetics, HMS

Robert D. Howe, PhD
Gordon McKay Professor of Engineering, Harvard University

Isaac S. Kohane, MD, PhD
Lawrence J. Henderson Professor of Pediatrics and Health Sciences and Technology, CHB

M. Charles Liberman, PhD
Professor of Otology and Laryngology and Health Sciences and Technology, MEEI

Bruce R. Rosen, MD, PhD
Professor of Radiology and Health Sciences and Technology, MGH

John J. Rosowski, PhD
Professor of Otology and Laryngology and Health Sciences and Technology, MEEI

Robert H. Rubin, MD
Gordon and Marjorie Osborne Professor of Health Sciences and Technology, HST
Professor of Medicine, BWH

Frederick J. Schoen, MD, PhD
Professor of Pathology and Health Sciences and Technology, BWH

Brian Seed, PhD
Professor of Genetics and Health Sciences and Technology, MGH

Daniel C. Shannon, MD
Professor of Pediatrics and Health Sciences and Technology, MGH

Mehmet Toner, PhD
Professor of Surgery and Health Sciences and Technology, MGH

Martin L. Yarmush, MD, PhD
Helen Andrus Benedict Professor of Surgery, Biological Chemistry, and Molecular Pharmacology, MGH

Associate Professors (Primary Appointment at MIT)

Elfar Adalsteinsson, PhD
Associate Professor of Health Sciences and Technology and of Electrical Engineering and Computer Science

Hugh M. Herr, PhD
Associate Professor in Media Arts and Sciences, and Health Sciences and Technology

Leonid A. Mirny, PhD
Samuel A. Goldblith Career Development
Associate Professor of Health Sciences and Technology and Physics

Collin M. Stultz, MD, PhD
Associate Professor of Health Sciences and Technology and of Electrical Engineering and Computer Science

Associate Professors (Primary Appointment at HMS and Affiliated Hospitals)

Brett Bouma, PhD
Associate Professor of Dermatology and Health Sciences and Technology, MGH

M. Christian Brown, PhD
Associate Professor of Otology and Laryngology, MEEI

Martha Bulyk, PhD
Associate Professor of Medicine and Health Sciences and Technology, BWH

Deborah Burstein, PhD
Associate Professor of Radiology and Health Sciences and Technology, BIDMC

W. H. Churchill Jr., MD
Associate Professor of Medicine and Health Sciences and Technology, BWH

Bertrand Delgutte, PhD
Associate Professor of Otology and Laryngology and Health Sciences and Technology, MEEI

Donald K. Eddington, PhD
Associate Professor of Otology and Laryngology and Health Sciences and Technology, MEEI

John J. Guinan, Jr., PhD
Associate Professor of Otology and Laryngology, MEEI

Robert E. Hillman, PhD
Associate Professor of Surgery and Health Sciences and Technology, MGH

Richard N. Mitchell, MD, PhD
Associate Professor of Pathology and Health Sciences and Technology, BWH

Associate Master for MD Program

Lee H. Schwamm, MD
Associate Professor of Neurology, MGH
Christopher A. Shera, PhD  
Associate Professor of Otology and Laryngology  
and Health Sciences and Technology, MEEI

A. G. Sorensen, MD  
Associate Professor of Radiology and Health  
Sciences and Technology, MGH

**Assistant Professors (Primary Appointment at HMS and Affiliated Hospitals)**

Kamran Badizadegan, MD  
Assistant Professor of Pathology and Health  
Sciences and Technology, BWH

Ulkan Demirci, PhD  
Assistant Professor of Medicine and Health  
Sciences and Technology, BWH

Alireza Khademhosseini, PhD  
Assistant Professor in Medicine and Health  
Sciences and Technology, BWH

Jennifer R. Melcher, PhD  
Assistant Professor of Otology and Laryngology  
and Health Sciences and Technology, MEEI

Shiladitya Sengupta, PhD  
Assistant Professor in Medicine and Health  
Sciences and Technology, BWH

Jagesh V. Shah, PhD  
Assistant Professor of Systems Biology, Medicine,  
and Health Sciences and Technology, BWH

Shamil R. Sunyaev, PhD  
Assistant Professor of Medicine and Health  
Sciences and Technology, BWH

**Instructor**

Jeffrey M. Karp, PhD  
Instructor in Medicine and Health Sciences and  
Technology, BWH

**Senior Lecturers**

Stephen K. Burns, PhD  
Teodoro F. Dagi, MD  
Howard L. Golub, MD, PhD  
Stanley N. Lapidus

**Lecturers**

Laurence I. Alpert, MD  
Jeffrey S. Behrens, MS, MBA  
Carl M. Berke, PhD  
Jeffrey Blander, ScD  
Jonathan P. Gertler, MD  
Linda C. Hemphill, MD  
Jacob Joseph, MD  
Susanne Klingenstein, PhD  
J. Christian Kryder, MD  
Steven M. Lulich, PhD  
Robert P. Marini, DVM  
Timothy A. Wagner, PhD  
Li Yuan Mi, PhD  
David-Huy Nhu Nguyen, PhD  
Shu-Hua Nong, PhD  
Neetu Singh, PhD  
Kannan Tharakan, PhD  
Karthik Viswanathan, PhD  
Brett G. Zani, PhD

**Research Staff**

**Senior Research Scientists**

Stan N. Finkelstein, MD  
James C. Weaver, PhD

**Principal Research Scientists**

Jane-Jane Chen, PhD  
Gari D. Clifford, PhD  
Julie E. Greenberg, PhD  
Chi-Sang Poon, PhD

**Research Scientists**

Mercedes Balcells-Camps, PhD  
James Delaney, PhD  
T. R. Gowrishankar, PhD  
Rahul Raman, PhD  
Andrew Reisner, PhD  
Gang Song, PhD  
Gregory H. Underhill, PhD

**Research Engineers**

Omar Abdala  
Michelle L. Farley  
Ramasubramanian Kaundinya, PhD  
Li-Wei H. Lehman, PhD  
George B. Moody  
Daniel J. Scott, PhD  
Mahadevan Venkataraman

**Research Associate**

Ann M. Lees, MD

**Postdoctoral Associates**

Eytan Abraham, PhD  
Udayanath Aich, PhD  
Natalie Artzi, PhD  
Aaron B. Baker, PhD  
Woo-Kyung Cho, PhD  
Axel Esser, PhD  
Ganpan Gao, PhD  
Shmuel Hess, PhD  
Laura Indolfi, PhD  
Vijaya B. Kolachalam, PhD  
Sandra March-Riera, PhD  
Ido Bachelet, PhD  
N. V. S. Rajasekhar Suragani, PhD  
David K. Wood, PhD  
Irene Bosch, PhD  
Qiaoling Hu, PhD  
Luismar Marques Porto, PhD  
Katherine Martin, PhD  
Igor B. Rozenvald, MD  
Viswanathan Sasisekharan, PhD  
Rajesh V. Swaminathan, MD  
Ganesh Venkataraman  
Stephen E. Zale, PhD  
Dina Uzri  
Qiang Zhu, PhD

**Professors Emeriti**

Walter H. Abelmann, MD  
Professor of Medicine, Emeritus, HMS  
Director, Alumni Affairs

Robert S. Lees, MD  
Professor of Health Sciences and Technology,  
Emeritus, MIT

Irving M. London, MD  
Professor of Medicine, Emeritus, HMS  
Professor of Biology, Emeritus, MIT

Kenneth N. Stevens, ScD  
Clarence J. Lebel Professor of Electrical  
Engineering and Health Sciences and  
Technology, Emeritus, MIT
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.

**Physical Oceanography**
Physical oceanography is the study of the physics of the ocean. Its central goal is to describe and explain the complex motions of the ocean. Principal research areas include general circulation, air-sea interaction, shelf dynamics, mesoscale processes, and small-scale processes. The Department of Earth, Atmospheric, and Planetary Sciences offers programs in physical oceanography with WHOI, which lead to the Doctor of Science or Doctor of Philosophy degree.

**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, 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 or from the Academic Programs Office at WHOI. 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://web.mit.edu/mit-whoi/www/.
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**

- 7.492J Methods and Problems in Microbiology
- 7.493J Microbial Genetics and Evolution
- 7.499 Research Rotations in Microbiology
- 7.57 Quantitative Biology for Graduate Students
- One of the following biochemistry subjects:
  - 7.51 Principles of Biochemical Analysis
  - 7.80 Biological Chemistry II

**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.

- 1.89 Environmental Microbiology
- 5.062 Principles of Bioinorganic Chemistry
- 5.451 Chemistry of Biomolecules and Natural Product Pathways
- 5.50 Enzymes: Structure and Function
- 5.52 Advanced Biological Chemistry
- 5.55 Chemical Tools for Assessing Biological Function
- 5.64 Biophysical Chemistry
- 5.65 Molecular Imaging

**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, approximately $29,000 in 2009–2010.

During the first year, students are supported by funds from the School of Science, the School of Engineering, the Provost’s Office, and the departments of Biological Engineering, Biology, Chemical Engineering, and Chemistry. 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/.
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 Advanced Visual Studies
- Center for Archaeological Materials
- Center for Biomedical Engineering
- Center for Biomedical Innovation
- Center for Collective Intelligence
- Center for Computational Research and Management Science
- Center for Educational Computing Initiatives
- 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 Technology, Policy, and Industrial Development
- Center for Transportation and Logistics
- Clinical Research Center
- Computer Science and Artificial Intelligence Laboratory
- Deshpande Center for Technological Innovation
- Division of Comparative Medicine
- Francis Bitter Magnet Laboratory
- Haystack Observatory
- Institute for Soldier Nanotechnologies
- Institute for Work and Employment Research
- Joint Program on the Science and Policy of Global Change
- Knight Science Journalism Fellows 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
- Materials Processing Center
- McGovern Institute for Brain Research
- Media Laboratory
- Microsystems Technology Laboratories
- Middle East Program at MIT
- MIT Center for Digital Business
- MIT Energy Initiative
- MIT Entrepreneurship Center
- MIT Kavli Institute for Astrophysics and Space Research
- MIT-Portugal Program
- MIT Professional Education
- Nuclear Reactor Laboratory
- Operations Research Center
- Picower Institute for Learning and Memory
- Plasma Science and Fusion Center
- Productivity from Information Technology Initiative
- Research Laboratory of Electronics
- Sea Grant College Program
- Singapore-MIT Alliance
- Spectroscopy Laboratory
- System Dynamics Group
- Technology and Development Program
- Whitaker College of Health Sciences and Technology
- Women’s and Gender Studies Program
- Other Affiliations
- 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 Advanced Visual Studies
The Center for Advanced Visual Studies is a fellowship program that commissions and produces new artworks and artistic research within the context of MIT. A laboratory for interdisciplinary art practice, the center facilitates exchange between internationally known contemporary artists and MIT’s faculty, students, and staff through public programs, support for long-term art projects, and residencies for MIT students.

CAVS was established in 1968 by Gyorgy Kepes, who emphasized the responsibilities of artists in building bridges between individuals and their environment, between individuals in groups, and between each of us and our inner lives. The center provided long-term appointments in its first decade to artists such as Maryanne Amacher, Stan van der Beek, Lowry Burgess, Peter Campus, Charlotte Moorman, Nam June Paik, Yvonne Rainer, Alan Sonfist, and many others. Under the direction of Otto Piene, projects reached an environmental scale; current director Krzysztof Wodiczko has brought attention to the relationships among science, technology, and contemporary culture.

Researchers at CAVS have pioneered the use of multimedia technologies, including lasers, plasma sculptures, sky art, and scientific visualization as tools of creative expression. Public lectures by artists such as Mel Chin, Marjetica Potrč, 16 Beaver Group, Vito Acconci, Miranda July, and others feed the residency program. Ongoing research includes Krzysztof Wodiczko’s Interrogative Design projects and Elizabeth Goldring’s Vision Arts. Major new projects by Michael Smith, the Center for Urban Pedagogy, and Xavier Le Roy expand the center’s work in new video projects, exhibitions, and choreography.

CAVS’s contributions to visual arts education at MIT have included Computational Art; Studio/Seminar in Public Art; Experiences in Interactive Expression; Art, Science, and Technology after the Cold War; Design, Technology, and Ethics: Tactical Design Workshop; and the freshman seminar Ethical Media Art. Although CAVS has no academic program of its own, it collaborates with the Visual Arts Program (Course 4) and the Media Laboratory on a wide range of projects.

For further information, contact the program coordinator, Meg Rotzel, Room N52-390, 617-253-4415, fax 617-253-1660, mrotzel@mit.edu. http://cavs.mit.edu/

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 palaeoecologies—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 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 including metallurgy, ceramics, photomicroscopy, 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...
Center for Biomedical Innovation

Launched in 2005, the MIT Center for Biomedical Innovation (CBI) is a collaboration among the MIT Schools of Engineering, Management, and Science, and the Harvard-MIT Division of Health Sciences and Technology. CBI’s mission is to improve global health by overcoming obstacles to the development and implementation of biomedical innovations.

CBI conducts collaborative research within a “safe haven” environment, with participation from faculty and students from MIT and Harvard, as well as senior scientists and executives from industry and government. Our primary areas of interest include:

- Safety assessment—Improve predictability in preclinical and clinical assessment and postmarketing surveillance through better use of informatics tools and data
- Research and development redesign—Enhance productivity through new collaboration and research models
- Manufacturing and distribution systems—Rationalize the supply chain and implement quality-by-design
- Risk management (economic and regulatory)—Apply systematic approaches that anticipate evolution in personalized health care, regulatory change, and reimbursement

CBI also offers graduate courses and sponsors lectures focused on emerging issues in biomedical innovation. This portfolio of educational initiatives is designed to address the need for scientific, technical, and managerial expertise required for innovating in the healthcare industries.

For more information, contact the Center for Biomedical Innovation, Room NE20-382, 617-253-0257, fax 617-253-0257, cbi@mit.edu.

http://web.mit.edu/cbi/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.

http://web.mit.edu/cci/www/

The Center for Collective Intelligence is directed by Professor Thomas W. Malone. For further information, contact Robert Laubacher, 617-253-0526, rjl@mit.edu.

http://cci.mit.edu/

Center for Computational Research 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 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 E53-383, 617-253-6601, rwelsch@mit.edu.

Center for Educational Computing Initiatives

The Center for Educational Computing Initiatives (CECI) is an interdepartmental research center that focuses on advanced technologies emerging for educational uses. Research at CECI involves the development of innovative technologies, the application of technologies to specific learning objectives, and the evaluation of the effectiveness of new technologies. Recent CECI projects have focused on the educational application of visualization, support for remote instrumentation, and the management of large scientific databases. CECI also evaluates how computer technology affects education, particularly how computer applications improve the quality of education.

Examples of CECI's current projects include:

- The Technology-Enabled Active Learning (TEAL) project. TEAL has reformed introductory physics education at MIT. It is designed to help students develop better intuition about, and conceptual models of, physical phenomena. This new approach to teaching is centered on active learning. It offers a highly collaborative, hands-on environment that makes extensive use of desktop experiments, educational technology, and computer-aided analysis of experimental data, giving students direct experience with basic physical phenomena such as electrical and magnetic fields.
- The iLabs project (http://icampus.mit.edu/projects/index.shtml). iLabs has developed a web services–based platform for the implementation of physical laboratories that can be operated remotely over the internet. This project, originally funded by Microsoft, has created an open specification and reference implementation of a software development kit. The software is used by laboratories in various departments at MIT and at several universities around the world.

Undergraduates may participate in CECI projects through the Undergraduate Research Opportunities Program.

For further information, contact Dean Steven R. Lerman, Room 3-138, 617-253-4277, lerman@mit.edu, or Dr. Judson Harward, Room 9-317, 617-253-7896, jud@mit.edu.

http://ceci.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. The center’s distinguishing characteristic is its dedication to high-quality, empirically-grounded economic analysis of corporate and public policy issues. An important component of CEEPR is the Joint Program on the Science and Policy of Global Change conducted with the MIT Center for Global Change Science.

For over 30 years, CEEPR has made important contributions to the analysis of energy markets, the organization and regulation of energy industries, the use of financial derivatives by energy companies, and the understanding of sources and effects of productivity change on energy demand and supply. CEEPR’s current research focuses on emissions trading, electric utility restructuring, and the effectiveness of environmental regulation.

Professor Henry D. Jacoby, of the MIT Sloan School of Management, is the center’s director. For more information, contact the executive director, John Parsons, E40-435, 617-324-3745, jparsons@mit.edu.


**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 36 CEHS members of MIT and Harvard University.

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 Science—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 Biological Engineering Department; 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 Biological Engineering Department integrates chemistry, molecular biology, and genetics with bioengineering approaches to the understanding of how organisms respond to environmental agents.

For further information, contact Professor Leona Samson, Room 56-235, 617-258-7813, lsamson@mit.edu.


**Center for Global Change Science**
The 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. The center’s main foci are global climate processes, climate observations, and past climate variations.

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; Electrical Engineering and Computer Science; Chemistry; Biology; Chemical Engineering; and the Woods Hole Oceanographic Institution. 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. Through the latter, CGCS sustains substantial collaborative effort with faculty, students, and researchers in the departments of Economics and Political Science, Sloan School of Management, Center for International Studies, and Engineering Systems Division.

CMI is a cooperative enterprise among CGCS scientists to develop a new generation model of the atmosphere, land, and ocean for study of the climate of the Earth. A focus of CMI is the MITgcm, a hydrodynamical model that can be used to study both the atmosphere and ocean. The approach encompasses elements of computational fluid dynamics, statistics, meteorology, oceanography, computer science, and exploits the latest understanding of geophysical and biogeochemical processes and new developments in algorithms, computing technology, and software design.

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-CO \(_2\) gases in the Kyoto Protocol (e.g., HFCs, methane, and nitrous oxide) to mitigate climate change.

MIT’s Joint Program on the Science and Policy of Global Change analyzes potential anthropogenic global climate change and its social and environmental consequences. The Joint Program integrates economics (energy and agriculture), climate and ecosystem dynamics, and biogeochemical cycles to probabilistically project future economic development, climate change, and air pollution under various assumptions regarding technologies and policies. The Joint Program was established in 1991 as a shared effort of the CGCS and the Center for Energy and Environmental Policy Research and is a key player in MIT’s Energy Initiative.

Professor Ronald Prinn of the Department of Earth, Atmospheric, and Planetary Sciences is the CGCS director. Contact the CGCS office at Room 54-1312, 617-253-4902, fax 617-253-0354, 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, multidisciplinary 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. The program’s teaching ties are primarily with the Political Science Department, and courses offered emphasize grand strategy, causes of conflict, military technology, bureaucratic politics, and budgetary issues. A special feature of the program is the integration of technical and political analyses in studies of international security problems, but the program’s prime task is educating those who will be the next generation of scholars and practitioners in international security policy making.

For more information on SSP, contact Joli Saraf, Room E40-477, 617-258-7608, fax 617-258-7858, joli@mit.edu.

The MIT International Science and Technology Initiative (MISTI) is MIT’s cornerstone program for international education. Through country programs in China, France, Germany, India, Israel, Italy, Japan, Mexico, Singapore, and Spain, MISTI places more than 350 students per year in internships with companies, research labs, and universities around the world. MISTI also supports MIT faculty members in cross-border research collaborations, works with institutes and universities on the transfer of OpenCourseWare information and iLab capability, facilitates research opportunities for international students and postdoctoral visitors at MIT, and arranges study opportunities for MIT students at selected universities abroad.

For more information, contact the program assistant, Room E40-428, 617-258-0385, fax 617-258-7432.

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 E40-417, 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 phrj@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 Rebecca Ochoa, E40-444D, 617-253-8306, fax 617-253-9330, rochoa@mit.edu.

The 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-Houlahan, E40-445, 617-258-8550, caseyj@mit.edu.

The briefing paper series, Audits of the Conventional Wisdom on US foreign policy, is part of the center’s public education program. Begun in spring 2005, the audits feature empirical analysis of pressing global issues, authored by MIT and guest scholars. They appear on the CIS website. 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 10 different departments, are engaged in CMSE research in the following areas:

- Nanomaterials for biological engineering
- Nanomaterials for electrochemical energy storage and conversion
- States of frustrated and correlated materials
- Mechanomutable heteronanomaterials
- Nanostructured fibers

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 Undergraduate Research Opportunities Program 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 a 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.

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 to undertake research activities and communication forums aimed at understanding and improving the physical real estate development process in the 21st century. This initiative is meant to be 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 challenge of the high cost of housing in eastern Massachusetts and elsewhere. Initial projects include 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 the nurturing of databanks and quantitative tools for the measurement of 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 also serves as the home for 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 12 months of intensive study.

For further information about the center or the Master of Science in Real Estate Development, contact Tony Ciochetti, chairman and director, Center for Real Estate, Room W31-310.

http://web.mit.edu/cre/

Center for Technology, Policy, and Industrial Development

MIT’s Center for Technology, Policy, and Industrial Development (CTPID) is an interdisciplinary research and educational center addressing global technology and policy issues through sustained partnerships with industry, government, and academia. These partnerships are aimed at supporting global economic growth and advancing policies that preserve the environment and benefit society at large.

CTPID research focuses on contemporary industrial problems—such as how to build safe, affordable, and environmentally friendly automobiles—that span social, natural, and technological interests.

Current programs, often supported by several corporations, address industry issues in aerospace, automotive, engineering and construction, information quality, materials systems, mobility, technology and law, and
healthcare. Other programs examine diverse issues facing a single global corporation. Applying CTPID’s interdisciplinary focus, a team—for example, of computer scientists, economists, and policy analysts—can join forces to solve whole problems, not just components of a problem.

Research from CTPID’s International Motor Vehicle Program (IMVP) resulted in The Machine That Changed the World, a book that articulated lean production techniques and transformed manufacturing worldwide. Recent books from CTPID’s diverse programs include The Second Century: Reconnecting Customer and Value Chain through Build-to-Order, Lean Enterprise Value: Insights from MIT’s Lean Aerospace Initiative, Future Cities: Dynamics and Sustainability, and Broadband: Bringing Home the Bits.

Center programs include the Ford-MIT Alliance, IMVP, Lean Advancement Initiative, Lean Sustainment Initiative, Information Quality Program (MIT IQ), Materials Systems Laboratory, and the Technology and Law Program.

Established in 1985, CTPID’s 45 faculty and researchers are drawn from MIT’s Schools of Engineering, Management, Humanities, Arts, and Social Sciences, and from peer institutions. Affiliated scholars come from universities including Harvard, Chicago, Tokyo, and Université de Paris XII. Pragmatic knowledge comes from over 40 sponsors, including Toyota Motor Corporation, Ford Motor Company, Raytheon Company, BAE Systems, Inc., the Boeing Company, the US Air Force, the US Army, and the National Science Foundation.

Sustained by MIT’s intellectual resources and interdisciplinary tools, CTPID’s mission is to develop new knowledge, advanced technological strategies, and innovative partnerships that support global industrial growth, social well-being, and environmental health.

For further information, contact the acting director, Joel Moses, E40-257, 617-253-8592. http://web.mit.edu/ctpid/www/

Center for Transportation & 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 MIT AgeLab.

Supply Chain Management and Logistics projects include Carbon Efficient Supply Chains; Demand Management; FreightLab; Healthcare Supply Chain; Scenario Planning; Strategy Alignment; Supply Chain 2020: The Future of the Supply Chain; Supply Chain Innovation in Emerging Markets; Supply Chain Security; and Supply Chain Network Risk Management.

Transportation projects include the New England University Transportation Center, MIT/Transit Professional Development Program, 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 Master of Engineering in Logistics program; the PhD program in Logistics and Supply Chain Management; and the MIT-Zaragoza International Logistics program, which offers graduate education in logistics and certificates 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 & Logistics and its programs, see Engineering Systems Division in Part 2. http://ctl.mit.edu/

Clinical Research Center
The MIT Clinical Research Center is an NIH-funded research facility on campus that provides an infrastructure for interested scientists to perform biomedical and nutritional research involving human subjects.

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 human nutrition and metabolism, psychiatry, neurology, endocrinology, physiology, infectious diseases (HIV), neuropsychology, biomechanical engineering, and obesity.

Most projects involve collaboration between physicians and clinical research scientists; some involve local hospitals such as Massachusetts General Hospital. 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 to assist in data collection for resting energy expenditure, body composition, hydration status and bone density. The center also provides a core lab to support processing of samples and conducting assays as necessary for each study. Nursing staff trained in both clinical practice and research procedures provide support to investigators for medical, biotech, and engineering clinical research.

Research opportunities are available for undergraduate and graduate students contemplating careers in the medical sciences and for postdoctoral physicians. The Undergraduate Research Opportunities Program 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. Undergraduates also have the opportunity to enroll in HST.S12 Introduction to Human Clinical Investigations, taught by Dr. Ravi Thadhani, MIT CRC codirector, and held at the CRC.

For further information, contact the program codirectors, doctors John Gabrieli and Ravi Thadhani, or the administrative officer, Dana Bresee Keeth, Room E18-422, 617-253-3091. http://web.mit.edu/crc/www/
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, 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.


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 Jaishree 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 $9 million in Ignition and Innovation Grants to support more than 80 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 is enabling MIT faculty and their students to pursue exciting new avenues of research on novel technologies. As a result, over 14 projects have spun out of the center as independent startups, having collectively raised more than $140M 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 to market leading-edge technologies from MIT’s world-renowned research laboratories. 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 on the web at [http://web.mit.edu/deshpandecenter/iteams/index.html](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 on the web at [http://web.mit.edu/deshpandecenter/portfolio.html](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. For more information, contact the Deshpande Center, Room 1-229, 617-253-0943, deshpandecenter@mit.edu.


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 one-on-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.


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 Science and 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/fbm/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, Haystack supports strong programs in both science and technology using VLBI, including unique mm-wavelength observations of the center of our galaxy to probe down to the size of the presumed black hole located there.

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 enhance the collecting area for radio observations, as well as ultra-broadband receiving systems for VLBI measurements.

Observatory researchers are currently leading the development of an array spanning 80–300 MHz called the Murchison Widefield Array in collaboration with the MIT Kavli Institute and others, which will be built in Western Australia. This innovative array offers rich opportunities for research in cosmology, astrophysics, and heliospheric science, and will open a broad new discovery space. Haystack scientists and engineers also are participating in the development of a new large array called the Square Kilometer Array for various astronomical studies.

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 Soldier Nanotechnologies

Since 2002, MIT has hosted the Institute for Soldier Nanotechnologies (ISN), an interdisciplinary research center established under contract with the US Army. ISN's mission is to develop nanomaterials and related nanotechnologies that will dramatically improve the protection and survivability of soldiers.

The ultimate goal is to create a 21st-century battlesuit that combines high-tech capabilities with light weight and comfort. Imagine a bullet-proof jumpsuit, no thicker than ordinary spandex, that monitors health, eases injuries, communicates automatically, and maybe even lends superhuman 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.

Another unique feature of ISN is that most theses are co-supervised by two or more faculty members representing different areas of technical expertise. Currently, affiliated faculty come from 10 MIT departments, including Biology, Biological Engineering, Materials Science and Engineering, Mechanical Engineering, Chemical Engineering, Electrical Engineering and Computer Science, Aeronautics and Astronautics, Chemistry, Mathematics, Physics, and the Harvard-MIT Division of Health Sciences and Technology.

In addition, many projects involve the participation of visiting experts both 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.

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 and MIT's 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, 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, 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 and brings together faculty and students at MIT and in the Boston area to discuss work in progress and serves as a major focal point for interest in this field.

IWER’s codirectors are Thomas A. Kochan and Paul Osterman. For more information, contact Jacalyn Martelli, Room E52-580, 617-258-8360, fax 617-253-7696, 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 conducts research and analysis on issues of global environmental change, with a concentration on climate, and communicates the results to the research community, policymakers, and the public. The program’s work focuses on the integration of natural and social science aspects of the climate issue to produce analyses relevant to ongoing national and international discussions. The effort involves an interactive group of faculty, staff, and student researchers.

Founded in 1991, the Joint Program combines the capabilities of two complimentary 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 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 program’s cornerstone is the MIT Integrated Global System Model (IGSM) of economic and environmental change. The IGSM is a comprehensive research tool for analyzing potential anthropogenic global climate change and its social and environmental consequences. The IGSM includes consideration of climate science, technical change, and economic and social science in an interacting set of computer models designed for study of the sensitivities and uncertainties that are crucial to policy evaluation.

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 governments working through their ministries and international organizations, and by independent research panels. Information is also communicated directly to international and national policy-making bodies, and to other investigators, through the program’s semiannual MIT Global Change Forum.

Professors Henry Jacoby, of the MIT Sloan School of Management, and Ronald Prinn, of the Department of Earth, Atmospheric, and Planetary Sciences, codirect the program. For further information, contact the program office, Room E40-428, 617-253-7492, fax 617-253-9845, globalchange@mit.edu.

http://web.mit.edu/globalchange/www/

Knight Science Journalism Fellows Program
Knight Science Journalism Fellowships are designed for 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 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 9-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 Boyce Rensberger, director, Room E19-307, 617-253-3442, boyce@mit.edu.

http://web.mit.edu/knight-science/

Koch Institute for Integrative Cancer Research
The David H. Koch Institute for Integrative Cancer Research at MIT, the former Center for Cancer Research, partially supported by the National Cancer Institute, provides facilities for interdisciplinary work in many areas of fundamental cancer research, including molecular, cellular, and developmental biology and immunology. With a $100 million gift from David H. Koch, MIT is building a new cancer research center—scheduled to open in 2010—that will bring together scientists and engineers under one roof to develop new and powerful ways to detect, diagnose, treat, and manage cancer.

The Koch Institute draws its faculty both from the School of Science and 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 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 E17-110, 617-253-6403.

http://web.mit.edu/ki/
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 Sara Salem, Room E52-450, 617-253-9745, fax 617-258-6855, ssalem@mit.edu.

http://lfe.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, communication, 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. Research at LIDS falls into four main areas.

Research in Communication and Networks includes fundamental work on networks, information theory, and communication theory. The work extends to applications in satellite, wireless and optical communications, and data networks. The objective is to develop the scientific base needed to design efficient, robust, and architecturally clean data communication networks. Topics of current interest include network architectures at all layers; power control; multiple antenna techniques; network coding; media access control protocols; routing in optical, wireless, and satellite networks; quality of service control; failure recovery; topological design; and the use of pricing as a mechanism for efficient resource allocation.

The Statistical Signal Processing 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 for this research include multisensor data assimilation for oceanography, hydrology, and meteorology; biomedical image analysis; object recognition and computer vision; and coordinated sensing and processing of large, distributed arrays of microsensors.

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, and computer-aided manufacturing. In addition to linear, nonlinear, dynamic, convex, and network programming, the solution of large-scale problems, including the application of neuro-dynamic programming methods, are also emphasized.

Control and System Theory group deals with problems related to complete systems analysis design, including learning and system identification, controller design and optimization, and basic analysis of distributed systems involving the interaction of information and control. Theoretical research quantifies the fundamental limitations and capabilities of learning and feedback control for various classes of systems in the presence of dynamic uncertainty. Application-oriented work includes control architectures for single and multiple unmanned aerial vehicles and controllers for piloting epitaxy in semiconductor manufacturing. Modeling aspects of the nervous system, conducted in collaboration with other laboratories are also a focus.

For further information about LIDS, contact the director, Professor Vincent W. S. Chan, Room 32-D608, 617-253-2142.

http://lids.mit.edu/

Laboratory for Manufacturing and Productivity

The Laboratory for Manufacturing and Productivity (LMP) is an interdepartmental center for education and research 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/
Theoretical research in both nuclear and particle physics is carried out within the Center for Theoretical Physics, described below. Another theoretical program investigates the properties of high-energy plasmas. In the nuclear physics experimental program, experiments continue at the Thomas Jefferson National Accelerator Facility, with polarized protons using RHIC at Brookhaven National Laboratory, and with neutrons at the Los Alamos Neutron Science Center. A continuation of the Bates electromagnetic program at higher energies is planned at the DESY accelerator in Germany. The high-energy particle physics program involves completing experiments at the Fermi National Accelerator Laboratory (FNAL) and analysis from experiments from the Stanford Linear Accelerator Center. A new program of experiments with both high-energy protons and heavy ions is now underway at the Large Hadron Collider at CERN in Switzerland. An experimental apparatus is being assembled that will be mounted on the International Space Station to look for antimatter in space and dark matter detector development is under way. Properties of neutrinos are being explored through experiments at FNAL, Karlsruhe, Germany, and Chooz, France.

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. For further information contact the director, Professor R. Milner, Room 26-505, 617-253-2395.

The William H. Bates Linear Accelerator Center is operated by the Laboratory for Nuclear Science as a research and engineering center with particular emphasis on accelerator science and technology, attracting faculty from across the Schools of Science and Engineering. Current efforts include the development of new techniques for interaction of lasers with particle beams, including optical cooling; design, construction, and testing of new detector systems; the design of the high-luminosity electron-ion collider eRHIC; and the development of Bates as a high-intensity photon radiation source. Bates is also the site of efforts to develop new techniques for screening of cargo for dangerous materials and for proton radiation for cancer therapy.

Students participate both through UROP projects and through undergraduate and graduate thesis work. For further information contact the director, Professor R. Redwine, Room 26-453, 617-253-3600.

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.

Students participate both through undergraduate UROP research and graduate thesis research. For further information contact the director, Professor E. Farhi, Room 8-323, 617-253-4871.

Lean Advancement Initiative
The Lean Advancement Initiative (LAI) is a research consortium that enables the focused and accelerated transformation of complex enterprises. LAI has members from industry, government, and academia and collaboratively engages all of its stakeholders to develop and institutionalize principles, processes, behaviors, and tools for enterprise excellence. Started in 1993, LAI resides within the Center for Technology, Policy and Industrial Development of the Engineering Systems Division (ESD) in the School of Engineering. Faculty from the Department of Aeronautics and Astronautics, ESD, and the MIT Sloan School of Management participate in LAI research. LAI has produced 25 case studies, 18 working/white papers, and 122 conference papers. More than 170 graduate students from Aeronautics and Astronautics, ESD, Mechanical Engineering, Sloan School of Management, and other programs have completed 170 master’s and doctoral theses within LAI.

LAI conducts its research in close collaboration with its industry and government members and has developed an array of tools to help its members assess and analyze their enterprises. These products include, but are not limited to, Lean Enterprise Self-Assessment Tool, Enterprise Transformation Roadmap, Enterprise Value Stream Mapping and Analysis, Systems Engineering Leading Indicators Guide, Enterprise Strategic Analysis for Transformation.

LAI’s Educational Network (EdNet) is an international group of more than 40 universities and colleges that develop and deploy curricula based on LAI’s latest research, practical knowledge, and member best practices. These curricula include: LAI Lean Academy®, LAI Lean Engineering Seminar™, LAI Lean Healthcare Academy™, Lean Enterprise Value Short Course, and customized courses.

LAI captured major findings in its 2003 award-winning book Lean Enterprise Value: Insights from MIT’s Lean Aerospace Initiative. Further information about LAI is available on the LAI website.

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 low-income countries. The fellowship provides financial and academic support including seminars and networking dinners with leaders in the entrepreneurial sphere. Throughout the school year, the center organizes conferences and a lecture series, which are open to the MIT and Cambridge community. For more information, contact legatum@mit.edu

Lincoln Laboratory
MIT’s Lincoln Laboratory, in Lexington, MA, is a federally sponsored center for research and development in advanced technologies in support of national security applications.

Lincoln Laboratory’s activities focus on design and development of complex systems, many of them incorporating new technologies, devices, and components.

Specific programs include optical and RF communications; missile defense technology; digital signal processing; embedded computer systems; image processing; space, air, and surface surveillance; biological defense sensors and systems; environmental monitoring; and air traffic control.
Research also is conducted in optics, solid-state devices, radar systems, decision support, and information technology.

Opportunities for research are available to MIT faculty members and qualified students. Inquiries may be directed to Zachary J. Lemnios, chief technology officer, LIN 53-305B, MIT Lincoln Laboratory, 244 Wood Street, Lexington, MA 02420-9108, 781-981-7020, or zlemnios@ll.mit.edu.

http://www.ll.mit.edu/

Materials Processing Center

The Materials Processing Center (MPC) is an interdisciplinary center within the School of Engineering. MPC 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.

In keeping with MIT’s educational mission, 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 students in their junior and senior years in college 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 on the Materials Processing Center, the MPC Industry Collegium, the Summer Scholar Program, or the Microphotonics Center, 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 advancing human understanding and communications. Its goal is to investigate and ultimately understand the biological basis of all higher brain function in humans.

At the McGovern Institute, the brain functions we study fall within three broad themes: perception, cognition, and action. These functions form a sequence from when we first perceive a sensory input, recognize it, evaluate it emotionally, make a decision about it, and finally have a behavioral reaction to it, which might be movement or speech. We seek to understand how these basic functions underlie all normal brain activity and how they go awry in mental disorders, brain diseases, and disabilities.

By determining how the brain works, from the level of gene expression in individual neurons to the interrelationships between complex neural networks, the McGovern Institute’s efforts work towards improving human health, discovering the basis of learning and recognition, and enhancing education and communication. Understanding the brain will foster better ways of communicating. The McGovern Institute’s work will ultimately contribute to the most basic knowledge of the fundamental mysteries of human awareness, decisions, and actions.

McGovern faculty hold primary appointments in academic departments at MIT, currently in the Department of Brain and Cognitive Sciences or the Department of Biology. When fully developed, the institute will have 16 faculty members. McGovern faculty members teach graduate students from a variety of disciplinary backgrounds, and also contribute to the undergraduate educational programs of their departments.

For further information contact the director, Dr. Robert Desimone, Room 46-3160, 617-324-0141.

http://web.mit.edu/mcgovern/

Media Laboratory

The Media Laboratory is about people, computation, and quality of life in a digital age. True to the vision of its founders, the laboratory 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 laboratory, 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 laboratory is engaged in research that includes computing culture, electronic publishing, software agents, multi-modal 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 laboratory 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 ap-
application to the arts (performance and the study of the principles of analysis and synthesis in computational media). Furthermore, the laboratory 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 laboratory’s research activities are conducted within the context of corporate-funded programs. The focus on corporate support reflects the laboratory’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 laboratory 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 laboratory sponsors.

For further information, contact Frank Moss, director, Room E15-401, 617-324-3818.

http://www.media.mit.edu/

Microsystems Technology Laboratories
The Microsystems Technology Laboratories (MTL) provide modern microelectronics fabrication laboratories, including cleanrooms, design and testing facilities to enable research and education in microelectronic/microfabrication technology. MTL microfabrication, testing, and computational facilities are open to the entire MIT community and researchers from other university or government laboratories, as well as limited industrial participation.

MTL facilities consist primarily of fully equipped cleanroom microfabrication laboratories and associated design, simulation, testing, and characterization infrastructure, as well as an extensive computational network, supporting a wide array of design and layout tools.

Process research and device fabrication at MTL are primarily conducted in three laboratories, the Integrated Circuits Laboratory (ICL), the Technology Research Laboratory (TRL) and the Exploratory Materials Laboratory (EML). ICL is 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 and provides facilities for the fabrication of novel micro and nano-structures. EML is a highly flexible microfabrication resource with all the basic fabrication capabilities and few limitations.

More than 130 faculty and senior research staff, 550 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.mit.edu. For information regarding MTL programs and other general information, contact Samuel Crooks, associate director for administration, 617-253-3978, crooks@mit.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.

This 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 networking to support development objectives.

The program is based on the participation of 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 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 health. 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 Carlene Doucette, Room NE20-336, 617-253-7054, fax 617-452-3231, carlened@mit.edu.

http://digital.mit.edu/

MIT Energy Initiative
The MIT Energy Initiative (MITEI) is designed to help transform the global energy system to meet the needs of the future and to help 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, described in greater detail below.

Two task forces help to define MITEI’s activities: the Energy Education Task Force, focused on developing educational opportunities for MIT
students; and the Campus Energy Task Force, focused on transforming the MIT physical plant and operations into a learning laboratory and on finding ways to “green the campus.” For more information about MITEI programs and activities, visit the website at http://web.mit.edu/mitei/.

Research
MITEI’s interdisciplinary research program focuses on:

• Innovative technologies and underlying policy analysis that will improve how we produce, distribute, and consume conventional energy
• Transformational technologies to develop alternative energy sources that can supplement and displace fossil fuels, including the economic, management, social science, and policy dimensions needed for this transformation
• Global systems to meet energy and environmental challenges through a multidisciplinary systems approach that integrates policy design and technology development
• Tools to enable innovation, transformation, and simulation of global energy systems through strategic basic research

Through its research program, MITEI addresses a critical link in the energy innovation chain, pairing MIT’s world-class research teams with the best in industry who will be responsible for moving the products of this collaboration into the energy marketplace. Those products include the development of enabling energy technologies that 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. The MITEI Education Office provides support to students through a variety of programs, including:

• An Institute-wide undergraduate Minor in Energy Studies, which was approved in spring 2009. Overseen by a faculty committee with representatives from all five Schools, the Energy 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.
• MITEI Energy Fellowships and networking of graduate fellows into a vital interdisciplinary community
• UROPs in energy and sustainability fields, using the MIT campus as a learning laboratory
• EnergyClasses and EnviroClasses—websites that can lead students to relevant classes across campus
• Campus Energy Activities that elicit cross-campus collaborations among students, faculty, and staff
• Support for student groups focusing on energy and the environment

The MITEI Education Office also supports the work of the Energy Education Task Force in pursuing three major goals: supporting the new undergraduate energy minor; assessing MIT’s existing energy curriculum; and establishing and communicating a model for interdisciplinary energy education at MIT.

For more information about the Energy Studies Minor or MITEI’s education program, contact Dr. Amanda C. Graham, director, Room E19-370K, 617-253-8995, agraham@mit.edu, or visit http://web.mit.edu/mitei/education/.

Campus Energy Activities
The MITEI campus energy program uses the MIT campus as a learning laboratory while seeking major reductions in campus-wide energy use. Among the activities are 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 resulting guidelines for use by other universities and institutions.

By drawing on faculty, staff, and students, the Campus Energy Task Force is well positioned to engage leading MIT energy experts, implement the newest approaches and technologies developed in their research, and build on the grounded expertise of MIT’s administrative and operational resources to make MIT’s campus a model of sustainability. These formal and informal collaborations have resulted in new energy conservation programs, sustainable building design features, student competitions, increased community awareness, and unique campus energy learning opportunities.

For more information, visit the campus energy program website at http://mit.edu/mitei/campus/. For information on campus energy infrastructure activities, contact Steven Lanou, deputy director for environmental sustainability, Environmental Health and Safety Office, slanou@mit.edu.

Laboratory for Energy and the Environment
The Laboratory for Energy and the Environment (LFEE) provides administrative support for the MIT Energy Initiative and operates under its umbrella to address complex interrelationships between energy and the environment. LFEE researchers consider the technological, economic, political, and social aspects of sustainable energy development and use, and of other environmental challenges to sustainable development.

LFEE is also the MIT home of the Alliance for Global Sustainability (AGS), an 11-year partnership of four research universities—University of Tokyo, ETH-Zürich, Chalmers University of Technology, and MIT. Working with industries, governments, and NGOs to develop sustainable solutions, AGS uses a fully integrated blend of research, education, and outreach to strengthen the knowledge needed for better decisions, policies, and technology development related to energy, food, and water. For more information, contact Professor David H. Marks, MIT coordinator for AGS, dhmarks@mit.edu.

Other programs in LFEE that support the work of MITEI include:

• The Analysis Group for Regional Energy Alternatives (AGREA), which performs scenario-based multi-attribution tradeoff analysis helping local and regional stakeholders identify robust portfolios of energy technology and policy options. Contact Stephen Connors, director, connorsr@mit.edu.
• The Center for Advanced Nuclear Energy Systems (CANES), which investigates how a better understanding of nuclear energy systems can improve the economics, safety, proliferation resistance, and
environmental impact of nuclear power. Contact Professor Mujid Kazimi, director, kazimi@mit.edu.

- The Center for Energy and Environmental Policy Research (CEEPR), described earlier in this section of the Bulletin.
- The Sloan Automotive Laboratory, which contributes to future developments in automotive technology through fundamental and applied research on propulsion technology and fuels. Contact Professor John B. Heywood, director, jheywood@mit.edu.

For more information on LFEI, visit http://lfee.mit.edu/.

MIT Entrepreneurship Center

The MIT Entrepreneurship Center (E-Center) educates and nurtures science, engineering, and management students who will make high-tech ventures successful. E-Center subjects, especially when combined with professional student club activities, provide the tools and develop the mindset that entrepreneurs need to design, launch, and build successful new enterprises.

All entrepreneurship subjects, described under Course 15 in the online MIT Subject Listing & Schedule (http://student.mit.edu/catalog/index.cgi), are available to graduate students from all MIT departments, and support the strong community of MIT entrepreneurship and innovation. Courses frequently feature invited speakers who have significant real-world experience to share. In addition, each January, the E-Center organizes the Entrepreneurship Development Program, an intense, one-week course for potential entrepreneurs and policy-makers from all over the world.

The MIT Entrepreneurship Center operates a global network of relationships with like-minded centers in Europe, the Middle East, and AustralAsia.

The E-Center also supports and cooperates closely with a wide array of related organizations at MIT, including the MIT $100K Entrepreneurship Competition, the MIT Venture Capital and Private Equity Club, the MIT Sloan Biomedical Business Club, the Sales Club, Sloan Entrepreneurs for International Development, the MIT Energy Club, the MIT Sloan Energy and Environment Club, the MIT Technology Licensing Office, the Deshpande Center for Technological Innovation, the Venture Mentoring Service, the Legatum Center for Development and Entrepreneurship, the MIT Enterprise Forum, the MIT Alumni Association, the MIT Sloan Career Development Office, and the Industrial Liaison Program.

Through these alliances, the MIT Entrepreneurship Center supports both faculty and students in research to better understand and enhance the high-tech entrepreneurship process.

Kenneth P. Morse is the managing director of the MIT Entrepreneurship Center, Professor Edward B. Roberts is chairman, William K. Aulet is the entrepreneur in residence, and José J. Pacheco is program manager.

For more information, contact the E-Center office, Room E40-196, 617-253-8653, fax 617-253-8633, ecenter@mit.edu.

http://entrepreneurship.mit.edu/

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 Mileura 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 to develop graduate 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.

Developed as part of the program are 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 a variety of MIT departments in the School of Engineering. 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 relationship on joint projects and serve as research (and occasionally teaching) assistants to faculty members. In addition, MPP has occasionally developed internship opportunities for MIT students to conduct research related to their work at Portuguese companies.
The program 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, Robin Lemp, Room E40-241, 617-253-0127.

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 professionals the opportunity to gain crucial knowledge in specialized fields to advance their careers, help their companies, and have an impact on the world.

MIT Professional Education comprises four programs:

- **Advanced Study Program (ASP, [http://advancedstudy.mit.edu/](http://advancedstudy.mit.edu/)).** Each term, professionals in engineering and technical fields come to MIT as fellows to gain knowledge and skills needed to advance their careers and bring innovative ideas and practices to their employers. While at MIT, they are enrolled as graduate students with full privileges. They plan their own academic experience, which may include courses from more than 30 disciplines, and some also arrange research opportunities with faculty in their field. Fellows earn grades, MIT credit, and an ASP certificate. Full-time fellows who complete two terms become MIT alumni.

- **Career Reengineering Program ([http://career-reengineering.mit.edu/](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/](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/](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 executive director Bhaskar Pant, Room 35-433, 617-452-4362, fax 617-258-8831.

http://professionaleducation.mit.edu/

**Nuclear Reactor Laboratory**

The MIT Nuclear Reactor Laboratory (NRL) is an interdepartmental center that operates a 5 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 $5 \times 10^{15}$ 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, including brain cancer therapy study; 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.

http://web.mit.edu/nrl/www/

**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.

http://web.mit.edu/orc/www/
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.

http://web.mit.edu/orc/www/

**Picower Institute for Learning and Memory**

The Picower Institute for Learning and Memory is an interdisciplinary research entity within the 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 and systems biology that explores the cognitive system as a whole.

Picower Institute investigators explore:

- How memory is formed through genetic, molecular, 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.

http://web.mit.edu/picower/

**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 9 tesla) with record-high plasma pressure particle densities. C-Mod’s present research program is aimed at understanding energy and particle transport at magnetic fields and densities comparable to that of future fusion reactors. In addition, it seeks to optimize plasma pressures with RF heating and non-inductive current profile control using high power RF transmitters (8MW 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, and the Levitated Dipole Experiment, a joint project with Columbia University. This experimental facility at PSFC studies the confinement, stability, heating, and transport of plasma particles and energy in a pure dipole magnetic configuration. World-renowned theoretical research is also carried out by scientists, students, and faculty in this division.

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. Recent work by 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 (~1000 gigabar), and field strength (~megagauss).

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 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 for both operating magnetic confinement experiments and advanced design projects. It also develops advanced high-field copper and superconducting magnet technology for the national fusion program and the high-energy physics community, and has been given an important role in the design and testing of the superconducting magnets for ITER, the next-step fusion device. The division also has expertise in magnet design for other fields, including the development of proton synchrotron accelerators for cancer treatment, magnetically levitated trains, and advanced superconducting materials.

Many academic departments are affiliated with PSFC, including the 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. Fifty-eight 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/

**Productivity from Information Technology Initiative**

Established in 1992, the Productivity from Information Technology (PROFIT) initiative explores how information technology can enhance productivity in both the private and public sectors. Its research spans diverse areas from finance to transportation, and from manufacturing to telecommunications. Current research efforts include knowledge acquisition (including the extraction of information from semi-structured web sources); knowledge management and integration (which includes the mapping and assembling of information across departmental, corporate, and national boundaries to suit new conditions and requirements); and knowledge dissemination.

For further information about PROFIT, contact Stuart Madnick, E53-321, 617-253-6671, fax 617-253-3321, smadnick@mit.edu; or Michael Siegel, E53-323, 617-253-2937, msiegel@mit.edu. http://mitsloan.mit.edu/research/profit/

**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:
- Circuits, systems, signals, and communications
- Physical sciences
- Quantum computation and communication
- Photonic materials devices and systems
- Nanoscale science and engineering
- Multiscale bioengineering and biophysics
- Electromagnetics, power, and energy

Seventy-one 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, 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.

Effective July 1, 2009, the Laboratory for Electromagnetic and Electronic Systems (LEES) will be 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, 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 the director, Professor Jeffrey H. Shapiro, Room 36-419, 617-253-4179. http://www.rle.mit.edu/

**Sea Grant College Program**

Through innovative research, education, outreach, and technology transfer, MIT Sea Grant promotes sustainable development and rigorous stewardship of our marine and coastal resources. We are part of the National Sea Grant College Program, a network of 32 programs funded by the National Oceanic and Atmospheric Administration.

Current areas of research include underwater communications, fisheries and aquaculture, coastal management, and marine biotechnology. The program is also home to the Autonomous Underwater Vehicles (AUV) Laboratory, which has been revolutionary in the development and testing of state-of-the-art, low-cost AUVs since its start in 1990. Education and outreach are also integral components of all our projects.

MIT departments principally involved in Sea Grant research include Mechanical Engineering, Civil and Environmental Engineering, Chemical Engineering, and Nuclear Science and Engineering. Graduate and undergraduate students participate in most Sea Grant research projects, and support is available for Undergraduate Research Opportunities Program projects.

Sea Grant also sponsors symposia and workshops, publishes reports, and works with local governments, businesses, and organizations to transfer both 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, 617-253-7042. http://seagrant.mit.edu/

**Singapore-MIT Alliance**

The Singapore-MIT Alliance (SMA) is a global partnership in graduate education created by MIT, the National University of Singapore (NUS), and Nanyang Technological University (NTU). 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.

Graduate programs are offered in four engineering disciplines and in one life science discipline: advanced materials for micro- and nano-systems; chemical and pharmaceutical engineering; computational engineering; manufacturing systems and technology; and computational and systems biology. The following programs will be offered in academic year 2009–2010.

The Advanced Materials for Micro- and Nano-Systems (AMMNS, http://web.mit.edu/sma/students/programmes/ammnss.htm) program offers a comprehensive and intensive approach to a field of study that is rapidly defining the frontier of modern technologies. The Department of Materials Science and Engineering hosts this degree at MIT. Students can earn dual degrees—a master of engineering in materials science and engineering from MIT and either a master’s or PhD degree from NUS.

The educational component of AMMNS exposes students to the broad foundations of advanced materials that encompass processing, structure, properties, and performance, with a particular emphasis on applications in microelectronics and emerging nanotechnologies. The research component of AMMNS provides an exceptional opportunity for collaboration between world-renowned faculty, and industry experts, both in Singapore and in the US. Students will also have the opportunity to interact with scientists and engineers at a number of research organizations, such as the Institute of Materials Research and Engineering and the Institute of Microelectronics.

The Chemical and Pharmaceutical Engineering (CPE, http://web.mit.edu/sma/students/programmes/cpe.htm) program offers a cutting-edge curriculum in the fields of molecular engineering and process science focused on the pharmaceutical industry. It offers a unique opportunity to obtain dual master of science degrees, one from the Chemical Engineering Practice Program of the Chemical Engineering Department at MIT and one from NUS. The dual degrees can be completed in three academic terms of coursework, and an additional term of industrial internship. The industry internship at a practice school station is in lieu of a research thesis. This program comprises innovative courses of study that integrate a molecular-level understanding of biological and chemical phenomena with advances in process engineering for the pharmaceutical and fine chemical industries.

The Computational Engineering (CE, http://web.mit.edu/sma/students/programmes/ce.htm) degree program is one of the most technologically advanced and critically acclaimed computational engineering programs. The School of Engineering hosts this degree at MIT. Students can earn dual degrees—a master of science in computation for design and optimization from MIT and either a master’s or PhD degree from NUS.

The educational component of CE is focused on educating the professionals who will model, simulate, optimize, and design the important engineered systems of the next decade and beyond. This educational track combines general methodology courses, discipline-specific electives, and industrial experience in a way that trains professionals for industry while also preparing doctoral students to participate in associated SMA interuniversity and flagship research projects.

The Computational and Systems Biology (CSB, http://web.mit.edu/sma/students/programmes/csb.htm) degree program is a partnership between the globally recognized CSBI program at MIT and the visionary biology, bioengineering, and biotechnology programs at NUS, NTU, and Singapore’s A*STAR Research Institutes. The Program in Computational and Systems Biology hosts this degree at MIT; graduates receive a PhD from either NUS or NTU, and have thesis co-supervision by an NUS/NTU faculty member and an MIT faculty member.

CSB research projects focus on the development of advanced technologies in biological probes, imaging, and computational biology, and the application of these technologies to medically relevant problems in tissue biology, including stem cell differentiation, tissue morphogenesis, infectious disease models, and tissue physiology.

The Manufacturing Systems and Technology (MST, http://web.mit.edu/sma/students/programmes/mst.htm) degree program is a comprehensive education and research effort that concentrates on enabling manufacturing systems and technologies for emerging industries in a global context. The program defines emerging industries as those based on new technologies that are just beginning to be considered for commercialization. Currently, this includes a host of new concepts in micro- and nanotechnology, such as molecular diagnosis, advanced drug screening, new ideas for photonic devices, microrobots, nanoscale optical devices, and a multitude of potential products employing micro- and nanoscale fluidics. The Department of Mechanical Engineering hosts this degree, at MIT. Students can earn dual degrees—a master of engineering in mechanical engineering from MIT and either a master’s or PhD degree from NTU.

For more information about SMA, contact the executive director, John C. Desforge, Room 8-407, 617-452-3014.

http://web.mit.edu/sma/

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 interdisciplinry 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 eight major laboratories: Pulsed Visible/UV Spectroscopy and Kinetics; Combustion Kinetics; Tri-Model Spectroscopy and Imaging; UV, Visible, and Near IR Raman Spectroscopy; Low-Coherence Interferometry; Spectroscopy of Quantum Dots; Spectroscopy of Condensed Phases; 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 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, and applications of lasers in medicine, including research in diagnosis of human biological tissue, in particular detection of early stages of cancer, using laser-induced fluorescence and light-scattering spectroscopy and phase microscopy using low-coherence interferometry, and cell biology.

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 director, Professor Michael Feld, Room NW14-1106, 617-253-7700. http://web.mit.edu/spectroscopy/

System Dynamics Group
Faculty and students in the System Dynamics Group use computer simulation and other tools to understand complex dynamics in a wide range of organizations, markets, and other settings. We work with these organizations to implement and assess the benefits of new policies to improve performance. Projects include the dynamics of process improvement, new product development, and service quality; environmental sustainability, including improving public understanding of climate change and policy for the transition from internal combustion and fossil fuels to alternative vehicles; improving public health, and others. Members of the group use a wide range of methods, from ethnographic field study to formal modeling. Many of the field studies and models provide the basis for simulation micro-worlds, or management flight simulators, where managers can experiment with policies for successful improvement without risk, accelerating individual and organizational learning. Such management flight simulators are now widely used in teaching and in organizations.

For further information, contact John Sterman, Room E53-351, 617-253-1951, fax 617-258-7579, jsterman@mit.edu. http://scripts.mit.edu/~sdg/

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. TDP currently is engaged in programs in Thailand and Abu Dhabi. The primary emphasis of each program is on institution building. Through research, education, and industrial outreach activities, the program provides opportunities for industry, government; and academia to pool their resources and enhance the domestic socioeconomic growth of the host country. In addition, TDP is intellectually involved with the Global Infrastructure Fund of Japan and with the Centro de Integración Fluvial de Sur América, Colombia, as well as other initiatives, such as the Disaster Relief Network.

TDP provides educational and research opportunities for master’s candidates interested in specific areas of technology and development. Admission to MIT must first be obtained from the appropriate academic department. The student should then submit a proposal for study to the TDP policy committee for approval. Details of the program are available upon request. Students may receive financial support in the form of research assistantships associated with current TDP research projects.

Further information about the program may be obtained from the director, Professor Fred Moavenzadeh, Room 1-173, 617-253-7178. http://web.mit.edu/mit-tdp/www/

Whitaker College of Health Sciences and Technology
In 1977, MIT established the Whitaker College of Health Sciences and Technology to provide an academic and administrative focus for the development of health-related activities at the Institute.

Many faculty members involved in the educational and research programs of Whitaker College hold joint appointments in the college and in other schools, departments, and interdisciplinary laboratories at MIT. Whitaker College includes the Center for Environmental Health Sciences, the Clinical Research Center, the Harvard-MIT Division of Health Sciences and Technology (HST), and the Division of Comparative Medicine. There are several graduate programs in Whitaker College. HST offers a number of graduate degree options that focus on different aspects of engineering and the biomedical sciences:

- The Program in Medical Engineering and Medical Physics leads to the PhD or ScD degree from MIT or the Harvard Faculty of Arts and Sciences.
- The Medical Sciences Program leads to the MD degree from Harvard Medical School.
- The Speech and Hearing Bioscience and Technology Program leads to the PhD or ScD degree from MIT.
- The Biomedical Enterprise Program leads to the SM in Health Sciences and Technology through HST.
- The Master of Engineering in Biomedical Engineering leads to the Master of Engineering (MEng) degree through HST.
- The Biomedical Informatics Training Program offers predoctoral and postdoctoral options from MIT and Harvard. Fellows have the option of pursuing the SM in Biomedical Informatics through HST.
- The Clinical Investigator Training Program trains postdoctoral physicians in patient-oriented research. Fellows in this program have the option to pursue a Master of Medical Sciences degree from Harvard.
- The Graduate Education in Medical Sciences Program is a certificate program that students in the MIT Schools of Engineering and Science may take concurrently with doctoral studies and research to gain exposure to biomedical and clinical sciences, including translational medicine.

http://web.mit.edu/vpr/www/whitaker.html
**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 roles 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 Undergraduate Research Opportunities Program 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.

To facilitate interdepartmental research, the Women’s Studies Research Room in the Humanities Library offers the MIT community a multidisciplinary resource for the study of women and gender. The Women’s and Gender Studies Program is described in greater detail under Interdisciplinary Undergraduate Programs and Minors in Part 3.

For further information, contact the coordinator, Heidy M. González, Room 14E-316, 617-253-8844.


**OTHER AFFILIATIONS**

**Broad Institute of MIT and Harvard**

Launched in 2004, the Broad Institute of MIT and Harvard is an unprecedented scientific organization that seeks to fulfill the promise of genomics for medicine by empowering creative and energetic scientists of all fields from across the MIT, Harvard, and the Harvard-affiliated hospitals to work together to transform medicine.

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 six core faculty members, with their primary labs located at Broad, and over 120 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 (MIT Building NE30), across the street from MIT’s Biology Department and adjacent to the Whitehead Institute, and at 320 Charles Street (MIT Building NE125).

Further information may be obtained through Broad Communications, 7 Cambridge Center, Cambridge, MA 02142, 617-452-3000.

[http://www.broad.mit.edu/](http://www.broad.mit.edu/)

**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 the continuation of joint research activities and to allow the laboratory to continue its unique contributions to the Institute’s educational program. Opportunities are available in the Course 6-A program, Space Grant, other programs, and for part-time employment. Research assistantships, denoted as Draper 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.

The laboratory’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 involves measurement, analysis, simulation, and control of complex dynamic systems, such as in robotics and autonomous vehicles. Draper is also applying its core competencies to a wide spectrum of applications, such as information systems, biomedical engineering, and commercial space systems.

A number of MIT faculty members maintain a close association with the laboratory, and thesis research opportunities exist that fulfill the residency requirement for an MIT degree in all phases of systems engineering, including basic theory, material sciences, mathematical analysis, computer studies, component design and evaluation (mechanical, electrical, and optical), and system synthesis. Students are in direct daily contact with the professional staff of engineers and scientists of the laboratory, and thus learn to appreciate the economic and human as well as the technical aspects of a system. Undergraduate and graduate students also may be employed by the laboratory and work directly on a project.

Adjacent to the main campus, Draper Laboratory is located at 555 Tech Square, Cambridge, MA 02139-3582. Information may be obtained by contacting Linda Fuhrman, 617-258-3259, or sending an email to ed@draper.com.


**Whitehead Institute for Biomedical Research**

Whitehead Institute for Biomedical Research 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’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.

The 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 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/
A
abroad, studying, 43–46. See also year away programs
absences from class or examinations, 72
for religious observance, 73–74
academic advisors, 33
academic calendar, 6–9
academic conduct, 76
academic credits. See credit hours for subjects
academic organization, 18
academic performance. See grading and academic performance
academic procedures, 70–79. See also policies and procedures
academic programs, 16–17
undergraduate, 17, 31–36
access to student records, 78–79
accreditation, 2, 17
ACT tests, 52
activities, cocurricular, 20, 43
administration, 18
admissions
graduate education, 63–64
undergraduate education, 51–53
Advanced Materials for Micro- and Nano-Systems, 318
Advanced Materials, Laboratory for, 160
Advanced Nuclear Energy Systems, Center for, 313
advanced placement, 51–52
Advanced Standing Examinations, 71–72
Advanced Study Program (professional education), 315
Advanced Visual Studies, Center for, 83, 300
advising and counseling, 20
academic advisors, 33, 71
careers, 47
Preprofessional Advising, 47
advising support, 20
Aeronautics and Astronautics, Department of, 106–117
aerospace and astronautics
Aerospace Computational Design Laboratory, 113
Aerospace Controls Laboratory, 113
Aerospace Studies curriculum, 69
Astrophysics Division, Physics Department, 270
atmospheric sciences, 257–262
Department of Aeronautics and Astronautics, 106–111
Kavli Institute for Astrophysics and Space Research, 314
Lean Advancement Initiative, 114, 310
Wallace Astrophysical Observatory, 260–261
African and African Diaspora Studies, Minor in, 281
Aga Khan Program for Islamic Architecture, 89
AgeLab, 156, 305
Air Force ROTC, 48–49
Alcator C-Mod Project, 187, 316
Alliance for Global Sustainability, 313
alumni, 18
Freshman/Alumni Summer Internship Program, 47
American Studies concentration, 277
AMP Mechanical Behavior of Materials Laboratory, 177
Analysis Group for Regional Energy Alternatives, 313
Ancient and Medieval Studies, 277
Anthropology program, 192–193
application for admissions
graduate education, 63–64
transfer students, 52–53
undergraduate education, 51
application for financial aid, 55–56
applied biosciences track (biological engineering), 120–121
Applied International Studies, Minor in, 205, 219, 277–278
applied mathematics, 264, 266
applied ocean science and engineering, 296
Aptitude Tests (GRE), 64
Archeological Materials, Center for, 300
Archeology and Materials, Minor in, 162
architecture. See also School of Architecture and Planning
Architectural Design program, 86
Center for Real Estate, 83, 304
Department of Architecture, 85–91
Department of Urban Studies and Planning, 94–100
minor programs in, 35
School of Architecture and Planning, about, 83–84
Architecture, Department of, 85–91
Architecture, Master of, 60
Army ROTC, 49–50
Art and Design, Bachelor of Science in, 86–87
artificial intelligence, 306
Artist-in-Residence Program, 21–22
arts, 20–22. See also HASS-D subjects
Center for Advanced Visual Studies (CAVS), 300
Center for BioMedical Innovation, 301
computational and systems biology, 243
bioengineering, 179
biological engineering specialty, 119–120
mechanical engineering specialty, 169, 170–171
Bioinstrumentation Laboratory, 179
Biological Engineering, Department of, 118–123
biology
biological oceanography, 295
computational and systems biology, 243
Computational and Systems Biology Initiative, 243, 287–288, 318
Department of Biological Engineering, 118–123
Department of Biology, 242–246
Institute requirements in, 36
interdisciplinary microbiology program, 297–298
Biology, Department of, 242–246
Biomechanics and Human Rehabilitation, Newman Laboratory for, 179
Biomechanics of Cells and Biomolecules, Laboratory for, 179
Biomedical Engineering, Center for, 300–301
Biomedical Enterprise Program, 289
Biomedical Informatics Program, 289–294
Biomedical Innovation, Center for, 301
biomedical studies
aerospace study and, 112
Biomedical Engineering, Master of Engineering in, 289
Biomedical Enterprise Program, 289
Biomedical Informatics Program, 289–294
Center for Biomedical Engineering, 300–301
Center for Biomedical Innovation, 301
Minor in Biomedical Engineering, 278–279
Whitehead Institute for Biomedical Research, 320–321
biophysical chemistry, 243
board of trustees (Corporation), 17
Boston, about, 15–16
INDEX

Literature Section, 214–215
living costs, graduate students, 66
living groups, 24–25
load status (undergraduates), 71
loans, 55, 68
Logistics, Master of Engineering in, 154

M
Madrid Program, 45
Magnetic Resonance Laboratory, 187
major Course of study, 34
Man Vehicle Laboratory, 114
management
Entrepreneurship Center, 229, 314
management science, 232
management studies, 233
minor programs in, 35
MIT Sloan Fellows Program in Innovation and Global Leadership, 234
Sloan School of Management, 228–238
Management Studies, Master of Science in, 60–61, 233
manufacturing
Laboratory for Manufacturing and Productivity, 177, 309
labs and centers at MIT, 177–179
Leaders for Global Operations (LGO) program, 112, 121, 129, 139, 148, 155, 165, 175, 233, 284–285
Manufacturing Systems and Technology program, 318
Master of Engineering degree, 169, 175
Manufacturing and Productivity Laboratory, for, 277, 309
MAP (Midcareer Acceleration Program). See Short Programs (professional education)
MArch degree. See Master of Architecture degree
marine engineering, 175
marine geology and geophysics, 295
Martin Center for Engineering Design, 178
MAS. See Media Arts and Sciences, Program in
Massachusetts College of Art cross-registration, 47
Massachusetts Space Grant Consortium, 110
Master in City Planning degree, 60, 61
Master of Architecture degree, 60
Master of Business Administration degree, 60, 232–233
Master of Engineering degree, 60
Master of Finance degree, 60, 233
Master of Science degree, 60
in Building Technology, 90
in Management Studies, 60–61, 233
in Real Estate Development (MSRED), 304
in Transportation, 139
in Visual Studies, 90
master’s degrees. See also graduate education programs; specific course or academic subject
general requirements, 60–61
simultaneous, 34, 38
simultaneous with bachelor’s degree, 61
Materials Processing Center, 311
materials studies
chemical engineering, 127–128
civil and environmental engineering, 138
Materials Science and Engineering, Center for, 304
Materials Science and Engineering, Department of, 160–168
mathematics
Department of Mathematics, 263–267
Institute requirements in, 37
MBA. See Master of Business Administration degree
McGovern Institute for Brain Research, 311
MCP. See Master in City Planning degree
meals (on campus), 23
-costs. See room and board
Mechanical Engineering, Department of, 169–182
Mechanics: Modeling, Experimentation, and Computation, 169, 177
media, campus, 23
media arts, 21. See also arts; Media Laboratory
Comparative Media Studies program, 194–196
freshman program in, 32
Program in Media Arts and Sciences, 32, 92–93
Media Arts and Sciences, Program in, 32, 92–93
Media Laboratory, 32, 83, 311–312
Medical Engineering and Medical Physics program, 290
Medical Imaging Technology, International Consortium for, 179
medical plan for students, 27
Medical Report forms, 56, 68
medical requirements for students, 56–57, 68–69
medical sciences, 290, 292
Koch Institute for Integrative Cancer Research, 14, 308
McGovern Institute for Brain Research, 311
medical services, 27
MEng. See Master of Engineering degree
microbiology, 243
interdisciplinary graduate program, 297–298
microelectromechanical systems, 171, 179
Microphotonics Center, 311
 Microsystems Technology Laboratories, 312
Midcareer Acceleration Program. See Short Programs (professional education)
Middle Eastern studies, 282, 312
Military Science and Leadership Program, 49
military training. See ROTC Programs
minor programs, 34–36, 62, 277–282. See also specific academic subject
in humanities, 35–36, 390, 201–203
in regional studies, 281–282
interdisciplinary, 277–282
miscellaneous fees, 54, 66. See also tuition and costs
mission statement of MIT, 13
MISTI (MIT International Science and Technology Initiative), 303
MIT Alumni Association, 18
MIT Bulletin, 2
MIT Corporation, 17
MIT Energy Initiative (MITEI), 312–314
MIT-Japan International Studies Fund Grants, 303
MIT Kavli Institute for Astrophysics and Space Research, 314
MIT-Madrid Program, 45
MIT Medical, 27
MIT Museum, 22
MIT Portugal Program, 314–315
MIT Press, 23
MIT Professional Education, 102, 315
MIT Sloan Management Review, 230
MITEL, 312–314
MITnet, 27
MITPAY system, 66
MKI. See Kavli Institute for Astrophysics and Space Research
MMEC. See Mechanics: Modeling, Experimentation, and Computation
molecular neuroscience, 249
motor vehicle policies, 23–24
MPP. See MIT-Portugal Program
MTL. See Microsystems Technology Laboratories
music, 21. See also arts
ASS-D subjects, 39–40
Music and Theater Arts Section, 216–218

N
nano/micro science and technology, 171, 179
Institute for Soldier Nanotechnologies, 307
nanostructures (chemical engineering), 128
architectural and marine engineering, 175
Naval Construction and Engineering program, 176
Naval ROTC, 50–51
neurobiology, 244
neuroscience, 247–252
New Century Development initiative, 304
Newman Laboratory for Biomechanics and Human Rehabilitation, 179
newsletter, student, 23
non-passing grades, defined, 75
non-payment policies, 54
nondiscrimination policy, 2
Nonlinear Science, Center for, 177
Nonlinear Systems Laboratory, 178
nonresident doctoral thesis research status, 62, 65
nuclear energy. See also energy studies
Center for Advanced Nuclear Energy Systems, 313
Department of Nuclear Science and Engineering, 183–188
Laboratory for Nuclear Science, 309–310
Nuclear and Particle Theory research, 270
Nuclear Reactor Laboratory, 187, 315
Nuclear Science and Engineering, Department of, 183–188
Nuclear Science, Laboratory for, 309–310
Nuclei and Particles, Division of, 270

O
Ocean Engineering, Center of, 178
occean science and engineering, 170, 175, 178
Center for Ocean Engineering, 178
Woods Hole Oceanographic Institution, Joint Program with, 295–296
OCW. See OpenCourseWare
off-campus housing, 26
off-campus misconduct, 76–77
off-campus opportunities. See also joint programs study at other universities, 45–47
Office of the Arts, 22
Office of the Dean for Graduate Education, 59
officers at MIT, 18
OpenCourseWare, 27–28
Operations Research Center, 315
operations research programs, 285
Optimization group (LIDS), 309
ORC. See Operations Research Center
organizing IAP activities, 43

P
Pappalardo Laboratory for Micro/Nano Engineering, 179
parenting resources, 24
Park Center for Complex Systems, 178
parking facilities, 23–24
Parsons Laboratory, 139
Partnership for AIR Transportation Noise and Emissions Reduction (PARTNER), 114
pass/fail. See grading and academic performance
passing grades, defined, 74–75. See also grading and academic performance
payment of tuition and other charges, 54–55, 66
Payment Plan, 54, 66
performance. See grading and academic performance
performing arts. See arts; music; theater arts
Persian Gulf Initiative, 303
personal conduct, 76–78
personal support, 20
philosophy studies, 210–213
Physical Education Requirement, 42–43
Physical Imagination, 20
Physical Oceanography, 295
physics
Department of Physics, 268–273
Institute requirements in, 37
Medical Engineering and Medical Physics program, 290
Physics, Department of, 268–273
Physics Research Division, 316
Picower Institute for Learning and Memory, 316
PLAN newsletter, 83
planetary sciences, 257–262
Minor in Astronomy, 270, 278
Planning, Bachelor of Science in, 94–96
plasma physics and fusion technology, 183, 270
Plasma Science and Fusion Center, 187, 316–317
PLAzmA Digital Gallery, 83
PoET (Program on Emerging Technologies), 303
policies and procedures
academic credits. See credit hours for subjects admissions. See admissions
costs. See financial aid; tuition and costs
General Institute Requirements, undergraduate, 36–43
grading. See grading and academic performance
integrity and conduct, 76–78
medical requirements, 56–57
nondiscrimination, 2
privacy of student records, 78–79
registration, 71–72
residence hall regulations, 25–26
term regulations and examination policies, 72–74
unpaid balances, 54–55
who determines, 18
political science
Department of Political Science, 219–221
Minor in Applied International Studies, 205, 219,
277–278
polymers, 127, 130
Bio- and Polymeric Materials program, 163
Program in Polymer Science and Technology, 130, 285
Portugal Program, 314–315
PPST. See Program in Polymer Science and Technology
Practice School, Chemical Engineering, 129
practice-school programs, 53, 65
Precision Engineering Laboratory, 178
Precision Systems Design and Manufacturing, 178
Preprofessional Advising, 47
preregistration, 70
prerequisites for subjects, 70
president, welcome from, 5
privacy of student records, 78–79
product design, manufacturing, and development, 169,
177–178
Productivity from Information Technology Initiative, 317
professional advising, 47
Professional Education, 102, 315
professional options, undergraduate, 47–51
proficiency requirements. See English language proficiency
Program in Computational and Systems Biology, 243,
287–288, 318
Program in Polymer Science and Technology, 130, 285
Program on Emerging Technologies (PoET), 303
Program on Human Rights and Justice, 303
programs, interdisciplinary. See interdisciplinary research and study
PSFC. See Plasma Science and Fusion Center
Psychology program, 248, 277, 280
Public Policy, Minor in, 96, 219, 280–281
Public Service Center (PSC), 8
publications, student, 23
pure (theoretical) mathematics, 264, 266
R
radio station, 23
Ralph M. Parsons Laboratory, 139
RAs. See research assistantships
Reacting Gas Dynamics Laboratory, 178
Real Estate, Center for, 83, 304
Real Estate Development, Master of Science in, 304
Regional Studies, Minors in, 281–282
registration, 71–72
regular graduate admissions, 63–64
regulations. See policies and procedures
reinstatement as student, 70
religious observances, absences caused by, 73–74
religious organizations on campus, 28
removal of services, 55
rent, housing. See housing
research assistantships, 67–68
biology, 244
brain and cognitive sciences, 249
chemistry, 255
earth, atmospheric, and planetary sciences, 260
economics, 198
management, 234
materials science and engineering, 166
mathematics, 266
mechanical engineering, 176–177
nuclear science and engineering, 187
Woods Hole Oceanographic Institution, 295–296
research centers. See centers at MIT
Research Laboratory of Electronics, 317
research labs. See labs at MIT
research opportunities, undergraduate, 44
research staff members, as graduate students, 64
residential system, 25–26, 55
REST Requirement, 40–41
Restricted Electives in Science and Technology. See
REST Requirement
RLE. See Research Laboratory of Electronics
Robert C. Seams Jr. Laboratory, 106
robotics
Controls, Instrumentation, and Robotics area, 169, 178
Field and Space Robotics Laboratory, 178
Roshenow Heat and Mass Transfer Laboratory, 178
room and board, 53. See also tuition and costs
graduate student living costs, 66
ROTC Programs, 42, 48–51
Rotch Library, 83
Russian Studies, Minor in, 282
Technology and Policy, Master of Science in, 112, 129, 148, 153–154, 166, 286
Technology Children’s Centers (TCC), 24
Technology-Enabled Active Learning (TEAL) project, 301
Technology Laboratory for Advanced Materials and Structures, 114
TEP. See Teacher Education Program
term away programs, 45–46
term regulations, 72–74
Terrascope Program, 32–33
teachers, 21. See also arts
HASS-D subjects, 39–40
Music and Theater Arts Section, 216–218
theoretical mathematics, 264, 266
Theoretical Physics, Center for, 270, 310
TOEFL tests, 52, 64
Toxicology and Environmental Health, Minor in, 118–119
TPP. See Technology and Policy, Master of Science in traineeships, 67
training programs, HST, 291–292
transcripts of grade reports, 76
transfer students
application for admissions, 52–53
application for financial aid, 56
transport processes and thermodynamics, 127
Transportation & Logistics, Center for, 156–157, 305
Transportation, Master of Science in, 139
Tufts University cross-registration, 63
tuition and costs. See also financial aid
graduate education, 65–67
graduate student living costs, 66
housing, 25–26
during Independent Activities Period (IAP), 43
payment of, 54–55
scholarships.
See also scholarships
undergraduate education, 53–55
21st-Century Energy, Center for, 178
Undergraduate Research Opportunities Program (UROP), 43–44, 109
undergraduate seminars, 44
undergraduate student government, 28–29
undergraduate students, about, 13
Unified Engineering, 108
unpaid balances, policy on, 54–55, 66–67
UPOP. See Undergraduate Practice Opportunities Program (UPOP)
upperclass students, financial aid for, 56
urban studies, 198
Department of Urban Studies and Planning, 94–100
Urban Design Certificate, 89, 98
Urban Studies and Planning, Department of, 94–100
UrLab India, 83

V
varsity athletics, 22, 42
Vehicle Technologies Sector (aerospace), 107
Versatile Toroidal Facility, 187
Veterans’ Benefits, 56, 68
Virgil Elings Center for Theoretical Physics, 270
visual arts, 21. See also arts
Master of Science in Visual Studies, 90
Visual and Performing Arts (HASS-D category), 39–40
Visual Arts group (architecture and planning), 86–87
voter registration, 78

W
WAC (Writing Across the Curriculum), 225–226
Wallace Astrophysical Observatory, 260
Wallace Geophysical Observatory, 260–261
Waves and Beams Division, 316
WebSIS website, 29
Wellesley cross-registration, 46–47, 62
WGS (Women’s and Gender Studies program), 277, 320
Whitaker College of Health Sciences and Technology, 319
Whitehead Institute for Biomedical Research, 320–321
William H. Bates Linear Accelerator Center, 310
wind tunnel, 115
WMBR radio station, 23
Wolk Gallery, 83
women’s studies
Graduate Consortium in Women’s Studies, 63, 320
Women’s and Gender Studies Program, 277, 320
Woods Hole Oceanographic Institution, Joint Program with, 295–296
biology studies, 244
civil and environmental engineering, 139
earth, atmospheric, and planetary sciences, 258
electrical engineering and computer science, 147
mechanical engineering, 176
Work and Employment Research, Institute for, 230, 307–308
work-study, 55, 67–68
Wright Brothers Wind Tunnel, 115

writing
  Communication Requirement, 37–38, 225
creative. See literary arts
journalism fellowships, 308
Science Writing, Graduate Program in, 225
Writing and Humanistic Studies program, 225–227
Writing Across the Curriculum, 225–226
Writing and Communication Center, 225
Writing and Humanistic Studies program, 225–227

Y
year away programs, 45–46, 110
About the Cover

Julie Mehretu’s densely layered Looking Back to a Bright New Future is one of a number of large-scale paintings described by the artist as “story maps of no location”—pictures of an imagined reality that could align with patterns of light and energy in the future world that MIT is intent on creating.

Julie Mehretu
Looking Back to a Bright New Future, 2003
Ink and acrylic on canvas
95 x 119 inches
241.3 x 302.3 cm
Collection Debra and Dennis Scholl
Courtesy of the artist and The Project, New York
© Julie Mehretu
Photo credit: Cameron Wittig

Cover design by Wilcox Design

Credits

Text design by Wilcox Design

Composed in Meta by MIT’s Reference Publications Office using Adobe InDesign™

Printed and bound by Hess Print Solutions, Brimfield, OH, on Manistique 100™ 35 pound 100% recycled paper and 10 point coated recycled cover stock

CD by Universal Millennium, Westwood, MA

Photos

Page 5: Donna Coveney; Pages 10–11, 17, 58, 70, 189, 274–275, 299: Stuart Darsch; Pages 12, 30, 80–81, 82, 101, 228, 239, 276, 283: Christopher Harting; Pages 14, 18, 19: Patricia Sampson;
Page 15: ©Andy Ryan; Page 16: Matt T. Yourst
**MIT Campus Map**

**Welcome to MIT**

In MIT's numbering system, the location of each room on the campus is indicated by its room number. In a typical room number, such as 7-121, the number preceding the hyphen is the building number; the first digit following the hyphen is the floor; and the last digits, the room. Thus Room 7-121 is in Building 7, on the first floor; Room 7-321 is directly above it, on the third floor.

On the main campus, buildings east of the Great Dome (Building 10) have even numbers; those to the west have odd numbers. You won't find Building 6 next to Building 5, for example. In addition, buildings west of Massachusetts Avenue are designated W; those north of the Connolly tracks, N; those east of Ames Street, E; and those north of the railroad and west of Massachusetts Avenue, NW.

An interactive map of MIT can be found at [http://whereis.mit.edu/](http://whereis.mit.edu/).
Visitor information

As parking is limited and regulations are aggressively enforced, visitors are strongly encouraged to use public transportation.

By public transportation, MBTA (“The T”) ①

A parking garage at Alewife Station (Routes 2 and 16 at the Cambridge/Belmont/Arlington line) allows access to the Red Line subway. Take the Red Line from Alewife Station in Cambridge or from Park Street Station in Boston to Kendall/MIT Station or to the Central Square Station, both of which are within walking distance of MIT. There is regular MBTA bus (W) service along Massachusetts Avenue from MIT to Boston and Harvard Square.

From Logan Airport by MBTA ①
Taxi fare is about $20–30. To travel by subway, at Logan Airport take the airport shuttle bus that runs to the Blue Line Subway Station. Take the Blue Line to the Government Center Station and go upstairs to board the Green Line Trolley to Park Street. At Park Street Station, go downstairs to board the Red Line Subway going outbound towards Alewife or exit at Kendall/MIT or Central Square Station.

By car from Logan Airport
Leaving the airport follow the signs to the Summer Tunnel. Entering the tunnel keep in the right lane for Storrow Drive North. Continue in the right lane following the Storrow Drive West signs. The tunnel you will see will be the Massachusetts Eye and Ear Infirmary on your left and the Charles River on your right. Keep to the right and continue to follow the Storrow Drive West signs. After passing under the Arthur Fiedler pedestrian walk bridge, change to the left lane and take exit for Massachusetts Avenue/Cambridge (2AN). Bear right and cross the Harvard Bridge. MIT’s main entrance at 77 Massachusetts Avenue will be on your right, at the third set of traffic lights.

By car from Route I-93 or Southeast Expressway
Take exit 26. Keeping in the right lane, follow the Storrow Drive West signs. After passing under the Arthur Fiedler pedestrian walk bridge, change to the left lane and take exit for Massachusetts Avenue/Cambridge (2AN). Bear right and cross the Harvard Bridge. MIT’s main entrance at 77 Massachusetts Avenue will be on your right, at the third set of traffic lights.

By car from Route I-90
Take the Cambridge/Allston Exit (18) on the left off of the Massachusetts Turnpike (Interstate 90). Bear right at the end of the ramp and go through two sets of traffic lights. Follow the signs to Cambridge. Cross the River Street Bridge and continue straight ahead for about one mile to Central Square. Turn right onto Massachusetts Avenue. MIT’s main entrance at 77 Massachusetts Avenue, is about one-half mile down on the left.

By car from Route I-95
The I-90 directions to MIT as given. From the south take I-90 off of I-95 and follow the I-90 directions to MIT as given.

Call a taxi
Yellow Cab
617-492-0500

Parking
MIT parking permit

Campus telephones

MIT house telephones are located in many of the campus buildings including the Student Center (map section D). To reach an office extension from a house telephone dial the last 5 digits (i.e. 3-4795) of the number. There are pay telephones in the Student Center (map section D), as well as other locations around the campus. To obtain MIT telephone numbers dial 617-253 1000 from a pay telephone or dial D (operator) from a campus telephone.