DEPARTMENT OF PHYSICS

The Department of Physics offers undergraduate, graduate, and postgraduate training, with a wide range of options for specialization.

The emphasis of both the undergraduate curriculum and the graduate program is on understanding the fundamental principles that appear to govern the behavior of the physical world, including space and time and matter and energy in all its forms, from the subatomic to the cosmological and from the elementary to the complex.

The Department of Physics strives to be at the forefront of many areas where new physics can be found. Consequently, the department works on problems where extreme conditions may reveal new behavior: from clusters of galaxies or the entire universe to elementary particles or the strings that may be the substructure of these particles; from collisions of nuclei at relativistic velocities that make droplets of matter hotter than anything since the Big Bang to laser-cooled atoms so cold that their wave functions overlap, resulting in a macroscopic collective state, the Bose-Einstein condensate; and from individual atoms to unusual materials, such as high-temperature superconductors and those that are important in biology. Pushing the limits provides the opportunity to observe new general principles and test theories of the structure and behavior of matter and energy.

Undergraduate Study

Bachelor of Science in Physics (Course 8)

An undergraduate degree in physics provides an excellent basis not only for graduate study in physics and related fields, but also for professional work in such fields as astrophysics, biophysics, engineering and applied physics, geophysics, management, law, or medicine. The undergraduate curriculum offers students the opportunity to acquire a deep conceptual understanding of fundamental physics. The core departmental requirements begin this process. The student then chooses one of two options to complete the degree: the focused option (http://catalog.mit.edu/degree-charts/physics-course-8/#focusedoptiontext) is designed for students who plan to pursue physics as a career, and is an excellent choice for students who want to experience as deep an engagement as possible with physics; the flexible option (http://catalog.mit.edu/degree-charts/physics-course-8/#flexibleoptiontext) also provides a very strong physics framework, and gives students who may want to pursue additional academic interests the flexibility to do so.

Both options lead to the same degree: the Bachelor of Science in Physics.

Physics: Focused Option

This option—which includes three terms of quantum mechanics, 36 units of laboratory experience, and a thesis—is ideal preparation for a career in physics.

In the second year, students take:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.03</td>
<td>12</td>
</tr>
<tr>
<td>8.033</td>
<td>12</td>
</tr>
<tr>
<td>8.04</td>
<td>12</td>
</tr>
<tr>
<td>8.044</td>
<td>12</td>
</tr>
<tr>
<td>8.223</td>
<td>6</td>
</tr>
</tbody>
</table>

Important skills for experimentation in physics may be acquired by starting an Undergraduate Research Opportunities Program (UROP) (http://catalog.mit.edu/mit/undergraduate-education/academic-research-options/undergraduate-research-opportunities-program) project.

In the third year, students normally take laboratory subjects:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.13</td>
<td>12</td>
</tr>
<tr>
<td>8.14</td>
<td>12</td>
</tr>
<tr>
<td>8.05</td>
<td>12</td>
</tr>
<tr>
<td>8.06</td>
<td>24</td>
</tr>
</tbody>
</table>

Students should also begin to take the restricted elective subjects, one in mathematics and at least two in physics. The mathematics subjects 18.04, 18.075, and 18.06 are particularly popular with physics majors. Topical elective subjects in astrophysics, biophysics, 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:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.07</td>
<td>12</td>
</tr>
<tr>
<td>8.08</td>
<td>12</td>
</tr>
<tr>
<td>8.09</td>
<td>12</td>
</tr>
</tbody>
</table>

An important component of this option is the thesis, which is a physics research project carried out under the guidance of a faculty member. Many thesis projects grow naturally out of UROP projects. Students should have some idea of a thesis topic by the middle of the junior year. A thesis proposal must be submitted before registering for thesis units and no later than Add Date of the fall term of the senior year.

A relatively large amount of elective time usually becomes available during the fourth year and can be used either to deepen one’s background in physics or to explore other disciplines.
Physics: Flexible Option

This option is designed for students who wish to develop a strong background in the fundamentals of physics and then build on this foundation as they prepare for career paths that may or may not involve a graduate degree in physics. Many students find an understanding of the basic concepts of physics and an appreciation of the physicist’s approach to problem solving an excellent preparation for the growing spectrum of nontraditional, technology-related career opportunities, as well as for careers in business, law, medicine, or engineering. Additionally, the flexible option makes it more possible for students with diverse intellectual interests to pursue a second major in another department.

The option begins with the core subjects:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.01</td>
<td>12</td>
</tr>
<tr>
<td>8.02</td>
<td>12</td>
</tr>
<tr>
<td>8.03</td>
<td>12</td>
</tr>
<tr>
<td>8.04</td>
<td>12</td>
</tr>
<tr>
<td>8.044</td>
<td>12</td>
</tr>
<tr>
<td>8.21</td>
<td>12</td>
</tr>
<tr>
<td>or 8.223</td>
<td></td>
</tr>
</tbody>
</table>

Students round out their foundation material with either an additional quantum mechanics subject (8.05) or a subject in relativity (8.20 or 8.033). There is an experimental requirement of 8.13 or, with the approval of the department, a laboratory subject of similar intensity in another department, an experimental research project or senior thesis, or an experimentally oriented summer externship. An exploration requirement consists of one elective subject in physics. Students can satisfy the departmental portion of the Communication Requirement by taking two of the following subjects:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.06</td>
<td>12</td>
</tr>
<tr>
<td>8.13</td>
<td>18</td>
</tr>
<tr>
<td>8.14</td>
<td>18</td>
</tr>
<tr>
<td>8.225</td>
<td>12</td>
</tr>
<tr>
<td>8.226</td>
<td>12</td>
</tr>
<tr>
<td>8.287</td>
<td>15</td>
</tr>
</tbody>
</table>

Inquiries

Additional information concerning degree programs and research activities may be obtained by contacting the department office (physics-undergrad@mit.edu), Room 4-315, 617-253-4841.
Master of Science in Physics

The normal degree program in the department leads to a PhD in Physics. Admission to a master’s degree program in Physics is available only in special cases (e.g., US military officers). The requirements for the Master of Science in Physics are the same as the General Degree Requirements (http://catalog.mit.edu/mit/graduate-education/general-degree-requirements) listed under Graduate Education. A 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

Candidates for the Doctor of Philosophy or Doctor of Science are expected to enroll in those basic graduate subjects that prepare them for the general examination, which must be passed no later than in the seventh term after initial enrollment. No specific subjects of study are prescribed, except for the requirement of two subjects in the candidate’s doctoral research area and two subjects outside the candidate’s field of specialization (breadth requirement). Half of the breadth requirement may be satisfied through a departmentally approved industrial internship. The doctoral thesis must represent a substantial piece of original research, carried out under the supervision of a department faculty member.

The Physics Department faculty members offer subjects of instruction and are engaged in research in a variety of fields in experimental and theoretical physics. This broad spectrum of activities is organized in the divisional structure of the department, presented below. Graduate students are encouraged to contact faculty members in the division of their choice to inquire about opportunities for research, and to pass through an apprenticeship (by signing up for Pre-Thesis Research) as a first step toward an engagement in independent research for a doctoral thesis.

Research Divisions

Faculty and students in the Department of Physics are generally affiliated with one of several research divisions:

- Astrophysics
- Experimental Nuclear and Particle Physics
- Atomic Physics, Biophysics, Condensed Matter Physics, and Plasma Physics
- Theoretical Nuclear and Particle Physics

Much of the research in the department is carried out as part of the work of various interdisciplinary laboratories and centers, including the Center for Materials Science and Engineering, Francis Bitter Magnet Laboratory, Haystack Observatory, Laboratory for Nuclear Science, Microsystems Technology Laboratories, MIT Kavli Institute for Astrophysics and Space Research, Plasma Science and Fusion Center, Research Laboratory of Electronics, and Spectroscopy Laboratory. Additional information about interdisciplinary laboratories and centers (http://catalog.mit.edu/mit/research) can be found under Research and Study. These facilities provide close relationships among the research activities of a number of MIT departments and give students opportunities for contact with research carried out in disciplines other than physics.

Inquiries

Additional information on degree programs, research activities, admissions, financial aid, teaching and research assistantships (physics-grad@mit.edu) may be obtained by contacting the department office, Room 4-315, 617-253-4851.

Faculty and Teaching Staff

Peter H. Fisher, PhD
Professor of Physics
Head, Department of Physics

Nergis Mavalvala, PhD
Curtis (1963) and Kathleen Marble Professor
Professor of Physics
Associate Head, Department of Physics

Professors

Raymond Ashoori, PhD
Professor of Physics

John Winston Belcher, PhD
Class of 1922 Professor
Professor of Physics

Edmund Bertschinger, PhD
Professor of Physics

Claude R. Canizares, PhD
Bruno B. Rossi Distinguished Professor in Experimental Physics
Professor of Physics

Deepto Chakrabarty, PhD
Professor of Physics

Arup K. Chakraborty, PhD
Robert T. Haslam (1911) Professor in Chemical Engineering
Professor of Chemistry
Professor of Physics
Core Faculty, Institute for Medical Engineering and Science
Isaac Chuang, PhD
Professor of Electrical Engineering
Professor of Physics
Janet Conrad, PhD
Professor of Physics
Bruno Coppi, PhD
Professor of Physics
Joseph A. Formaggio, PhD
Professor of Physics
Nuh Gedik, PhD
Professor of Physics
Alan Guth, PhD
Victor F. Weisskopf Professor in Physics
Jacqueline N. Hewitt, PhD
Julius A. Stratton Professor
Professor of Physics
Scott A. Hughes, PhD
Professor of Physics
Robert L. Jaffe, PhD
Otto (1939) and Jane Morningstar Professor of Science
Professor of Physics
Pablo Jarillo-Herrero, PhD
Cecil and Ida Green Professor of Physics
John D. Joannopoulos, PhD
Francis Wright Davis Professor
Professor of Physics
Steven G. Johnson, PhD
Professor of Mathematics
Professor of Physics
David I. Kaiser, PhD
Germeshausen Professor of the History of Science
Professor of Physics
Mehran Kardar, PhD
Francis L. Friedman Professor of Physics
Wolfgang Ketterle, PhD
John D. MacArthur Professor
Professor of Physics
Markus Klute, PhD
Professor of Physics
Patrick A. Lee, PhD
William and Emma Rogers Professor
Professor of Physics
Leonid Levitov, PhD
Professor of Physics
Hong Liu, PhD
Professor of Physics
Seth Lloyd, PhD
Professor of Mechanical Engineering
Richard G. Milner, PhD
Professor of Physics
Leonid A. Mirny, PhD
Professor of Physics
Core Faculty, Institute for Medical Engineering and Science
Christoph M. E. Paus, PhD
Professor of Physics
Miklos Porkolab, PhD
Professor of Physics
David E. Pritchard, PhD
Cecil and Ida Green Professor of Physics
Krishna Rajagopal, PhD
Professor of Physics
Robert P. Redwine, PhD
Professor of Physics
Gunther M. Roland, PhD
Professor of Physics
Sara Seager, PhD
Class of 1941 Professor of Planetary Sciences
Professor of Physics
Professor of Aeronautics and Astronautics
Robert A. Simcoe, PhD
Francis L. Friedman Professor of Physics
Professor of Physics
Marin Soljačić, PhD
Professor of Physics
Iain Stewart, PhD
Professor of Physics
Washington Taylor IV, PhD
Professor of Physics
Max Erik Tegmark, PhD
Professor of Physics
Samuel C. C. Ting, PhD
Thomas D. Cabot Institute Professor
Professor of Physics
Professor of Physics
Senthil Todadri, PhD
Professor of Physics

Vladan Vuletić, PhD
Lester Wolfe Professor
Professor of Physics

Xiao-Gang Wen, PhD
Cecil and Ida Green Professor in Physics

Frank Wilczek, PhD
Herman Feshbach (1942) Professor of Physics
(On leave, fall)

Boleslaw Wyslouch, PhD
Professor of Physics

Barton Zwiebach, PhD
Professor of Physics

Martin Wolfram Zwierlein, PhD
Professor of Physics

**Associate Professors**
Joseph George Checkelsky, PhD
Mitsui Career Development Professor
Associate Professor of Physics

Ibrahim I. Cissé, PhD
Associate Professor of Physics
Associate Professor of Biology

William Detmold, PhD
Associate Professor of Physics

Matthew J. Evans, PhD
Mathworks Physics Professor
Associate Professor of Physics

Nikta Fakhri, PhD
Associate Professor of Physics

Anna L. Frebel, PhD
Associate Professor of Physics

Liang Fu, PhD
Associate Professor of Physics

Jeff Gore, PhD
Associate Professor of Physics

Aram W. Harrow, PhD
Associate Professor of Physics

Yen-Jie Lee, PhD
Associate Professor of Physics

Nuno F. Loureiro, PhD
Associate Professor of Nuclear Science and Engineering
Associate Professor of Physics

Michael McDonald, PhD
Associate Professor of Physics

Tracy Robyn Slatyer, PhD
Associate Professor of Physics

Jesse Thaler, PhD
Associate Professor of Physics

Member, Institute for Data, Systems, and Society

Mark Vogelsberger, PhD
Associate Professor of Physics
(On leave)

Michael Williams, PhD
Associate Professor of Physics

Lindley Winslow, PhD
Associate Professor of Physics

**Assistant Professors**
Riccardo Comin, PhD
Class of 1947 Career Development Professor
Assistant Professor of Physics

Netta Engelhardt, PhD
Assistant Professor of Physics

Ronald Garcia Ruiz, PhD
Assistant Professor of Physics

Daniel Harlow, PhD
Assistant Professor of Physics

Philip Harris, PhD
Assistant Professor of Physics

Or Hen, PhD
Assistant Professor of Physics

Long Ju, PhD
Assistant Professor of Physics

Erin Kara, PhD
Assistant Professor of Physics

Kiyoshi Masui, PhD
Assistant Professor of Physics

Max Metlitski, PhD
Assistant Professor of Physics
Kerstin Perez, PhD
Class of 1948 Career Development Professor
Assistant Professor of Physics

Phiala E. Shanahan, PhD
Class of 1957 Career Development Professor
Assistant Professor of Physics

Salvatore Vitale, PhD
Assistant Professor of Physics

Adjoint Professors
William A. Barletta, PhD
Adjunct Professor of Physics

Senior Lecturers
Peter Dourmashkin, PhD
Senior Lecturer in Physics

Lecturers
Mohamed Abdelhafez, PhD
Lecturer in Physics

Sean P. Robinson, PhD
Lecturer in Physics
Technical Instructor of Physics

Michelle Tomasik, PhD
Lecturer in Physics

Technical Instructors
Caleb C. Bonyun, MS
Technical Instructor of Physics

Aidan MacDonagh, BSE
Technical Instructor of Digital Learning

Andy Neely, BS
Technical Instructor of Physics

Gladys Velez Caicedo, BS
Technical Instructor of Physics

Joshua Wolfe, BS
Technical Instructor of Physics

Research Staff

Senior Research Scientists
Earl S. Marmar, PhD
Senior Research Scientist of Physics

Jagadeesh Moodera, PhD
Senior Research Scientist of Physics

Richard J. Temkin, PhD
Senior Research Scientist of Physics

Professors Emeriti

George B. Benedek, PhD
Alfred H. Caspary Professor Emeritus of Physics
Professor Emeritus of Biological Physics

Ahmet Nihat Berker, PhD
Professor Emeritus of Physics

William Bertozzi, PhD
Professor Emeritus of Physics

Robert J. Birgeneau, PhD
Professor Emeritus of Physics

Hale V. Bradt, PhD
Professor Emeritus of Physics

Wit Busza, PhD
Professor Emeritus of Physics

Min Chen, PhD
Professor Emeritus of Physics

George W. Clark, PhD
Professor Emeritus of Physics

Edward Farhi, PhD
Cecil and Ida Green Professor Emeritus of Physics

Daniel Z. Freedman, PhD
Professor Emeritus of Mathematics
Professor Emeritus of Physics

Jerome I. Friedman, PhD
Institute Professor Emeritus
Professor Emeritus of Physics

Jeffrey Goldstone, PhD
Professor Emeritus of Physics

Thomas J. Greytak, PhD
Professor Emeritus of Physics

Lee Grodzins, PhD
Professor Emeritus of Physics

Erich P. Ippen, PhD
Elihu Thomson Professor Emeritus
Professor Emeritus of Physics
Professor Emeritus of Electrical Engineering

Roman Wladimir Jackiw, PhD
Jerrold Zacharias Professor Emeritus of Physics
Professor Emeritus of Physics
Paul Christopher Joss, PhD
Professor Emeritus of Physics

Marc A. Kastner, PhD
Donner Professor of Science Emeritus
Professor Emeritus of Physics

Vera Kistiakowsky, PhD
Professor Emerita of Physics

Daniel Kleppner, PhD
Lester Wolfe Professor Emeritus
Professor Emeritus of Physics

Stanley B. Kowalski, PhD
Professor Emeritus of Physics

J. David Litster, PhD
Professor Emeritus of Physics

Earle L. Lomon, PhD
Professor Emeritus of Physics

June Lorraine Matthews, PhD
Professor Emerita of Physics

Ernest J. Moniz, PhD
Cecil and Ida Green Distinguished Professor Emeritus
Professor Emeritus of Physics
Professor Emeritus of Engineering Systems

John W. Negele, PhD
William A. Coolidge Professor Emeritus
Professor Emeritus of Physics

Irwin A. Pless, PhD
Professor Emeritus of Physics

Saul A. Rappaport, PhD
Professor Emeritus of Physics

Lawrence Rosenson, PhD
Professor Emeritus of Physics

Paul L. Schechter, PhD
William A. M. Burden Professor Emeritus in Astrophysics

Rainer Weiss, PhD
Professor Emeritus of Physics

James E. Young, PhD
Professor Emeritus of Physics