DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

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 (EECS) (*http://www.eecs.mit.edu*) 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 wide range 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 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.

Undergraduate Study

For MIT undergraduates, the Department of Electrical Engineering and Computer Science offers several programs leading to the Bachelor of Science. Students in 6-1, 6-2, 6-3, 6-4, 6-7, 6-9, or 6-14 may also apply for one of the Master of Engineering programs offered by the department, which require an additional year of study for the simultaneous award of both the bachelor's and master's degrees.

Bachelor of Science in Electrical Science and Engineering (Course 6-1)

The 6-1 program (*http://catalog.mit.edu/degree-charts/electrical-science-engineering-course-6-1*) leads to the Bachelor of Science in Electrical Science and Engineering. The program starts with three foundation courses in circuits, signal processing, and computer architecture. Those are followed by specialization in three header subjects chosen from signals, nanoelectronics, electromagnetics, neurophysiology, or machine learning; two advanced undergraduate subjects; and two elective subjects from an extensive set of possibilities.

Bachelor of Science in Electrical Engineering and Computer Science (Course 6-2)

The 6-2 program (*http://catalog.mit.edu/degree-charts/electrical-engineering-computer-science-course-6-2*) leads to the Bachelor of Science in Electrical Engineering and Computer Science and is for students whose interests focus on creating systems that interface with the world, digital design and computer architecture, and control systems. The degree has a required foundation of 4.5 subjects in basic mathematics, programming, and algorithms. Students build on these fundamental subjects with 3 core system design subjects encompassing the discipline, along with an integrative system design laboratory class. There are then four subjects drawn from a range of application tracks, one communication-intensive subject, and one additional elective.

Bachelor of Science in Computer Science and Engineering (Course 6-3)

The 6-3 program (*http://catalog.mit.edu/degree-charts/computer-science-engineering-course-6-3*) leads to the Bachelor of Science in Computer Science and Engineering and is designed for students whose interests focus on software, computer systems, and theoretical computer science. The degree has a required core of 2.5 subjects in programming, 2.5 subjects in systems, and 3 subjects in algorithmic thinking and theory, along with a math subject in either linear algebra or probability and statistics. Students then take two upper-level courses in each of two specialized tracks, including computer architecture, human-computer interaction, programming tools and techniques, computer systems, or theory. 6-3 students may alternatively choose an electrical engineering track from the 6-2 degree, or an artificial intelligence and decision-making track from the 6-4 degree.

Bachelor of Science in Artificial Intelligence and Decision Making (Course 6-4)

The 6-4 program (*http://catalog.mit.edu/degree-charts/artifical-intelligence-decision-making-course-6-4*) leads to the Bachelor of Science in Artificial Intelligence and Decision Making and is designed for students whose interests focus on algorithms for learning and reasoning, applications of artificial intelligence, and connections to natural cognition. The degree has a required foundation of 5.5 subjects in basic mathematics and computer science; a breadth requirement of 5 subjects covering data, model, decision, computation, and human-centric areas; two subjects drawn from applications or other advanced material; one additional breadth subject; and one additional communications-intensive subject.

Bachelor of Science in Computer Science and Molecular Biology (Course 6-7)

The 6-7 program (*http://catalog.mit.edu/degree-charts/computer-science-molecular-biology-course-6-7*) leads to the Bachelor of Science in Computer Science and Molecular Biology. Offered jointly by the Department of Electrical Engineering and Computer Science and the Department of Biology (Course 7), the program is for students who wish to specialize in computer science and molecular biology. Students begin with introductory courses in math, chemistry, programming, and lab skills. They then build on these skills with five courses in algorithms and biology, which lead to a choice of electives in biology, with a particular focus on computational biology. Additional information about the 6-7 program (*http://catalog.mit.edu/interdisciplinary/undergraduate-programs/degrees/computer-science-molecular-biology*) can be found in the section Interdisciplinary Programs.

Bachelor of Science in Computation and Cognition (Course 6-9)

The 6-9 program (*http://catalog.mit.edu/degree-charts/computation-cognition-6-9*) leads to the Bachelor of Science in Computation and Cognition. Offered jointly by the Department of Electrical Engineering and Computer Science and the Department of Brain and Cognitive Sciences (Course 9), the program focuses on the emerging field of computational and engineering approaches to brain science, cognition, and machine intelligence. It is designed to give students access to foundational and advanced material in electrical engineering and computer science, as well as in the architecture, circuits, and physiology of the brain. Additional information about the 6-9 program (*http://catalog.mit.edu/interdisciplinary/undergraduate-programs/degrees/computation-cognition*) can be found in the section Interdisciplinary Programs.

Bachelor of Science in Computer Science, Economics, and Data Science (Course 6-14)

The 6-14 program (*http://catalog.mit.edu/degree-charts/computer-science-economics-data-science-course-6-14*) leads to the Bachelor of Science in Computer Science, Economics, and Data Science. Offered jointly by the Department of Electrical Engineering and Computer Science and the Department of Economics (Course 14), this program is for students who wish to specialize in computer science, economics, and data science. It is designed to equip students with a foundational knowledge of economic analysis, computing, optimization, and data science, as well as hands-on experience with empirical analysis of economic data. Students take eight subjects that provide a mathematical, computational, and algorithmic basis for the major. Students then take two subjects in data science, two in intermediate economics, and three elective subjects from data science and economics theory. Additional information about the 6-14 program (*http://catalog.mit.edu/interdisciplinary/undergraduate-programs/degrees/computer-science-economics-data-science*) can be found in the section Interdisciplinary Programs.

Bachelor of Science in Urban Science and Planning with Computer Science (Course 11-6)

The 11-6 program (*http://catalog.mit.edu/degree-charts/urban-science-planning-computer-science-11-6*) leads to the Bachelor of Science in Urban Science and Planning with Computer Science. This program, offered jointly by the Department of Electrical Engineering and Computer Science and the Department of Urban Studies and Planning (Course 11), is for students who wish to specialize in urban science and planning with computer science. Additional information about the 11-6 program (*http://catalog.mit.edu/interdisciplinary/undergraduate-programs/degrees/urban-science-planning-computer-science*) can be found in the section Interdisciplinary Programs.

Minor in Computer Science

The department offers a Minor in Computer Science. The minor provides students with both depth and breadth in the field, as well as the opportunity to explore areas of their own interest.

To complete the minor, students must take at least six subjects (six-unit subjects count as half-subjects) totaling at least 72 units from the lists below, including:

- at least one software-intensive subject, and
- one algorithms-intensive subject at either the basic or advanced level.

Introductory Level		
Select up to 12 units of the following:		12
6.100A	Introduction to Computer Science Programming in Python	
6.100B	Introduction to Computational Thinking and Data Science	
6.3400	Introduction to EECS via Communication Networks	
6.9010	Introduction to EECS via Interconnected Embedded Systems	
6.9080	Introduction to EECS via Robotics	
Basic Level		
Select up to 63 units of the following:		63

6.1200[J]	Mathematics for Computer Science	
6.1910	Computation Structures	
6.3700	Introduction to Probability	
6.3800	Introduction to Inference	
6.4100	Artificial Intelligence	
18.200	Principles of Discrete Applied Mathematics	
18.200A	Principles of Discrete Applied Mathematics	
18.211	Combinatorial Analysis	
Algorithms-intensive		
6.1210	Introduction to Algorithms	
Software-intensive		
6.1010	Fundamentals of Programming	
Advanced Level		
Select at least 12 units of the following:		12
6.1220[J]	Design and Analysis of Algorithms	
6.1400[J]	Computability and Complexity Theory	
6.1800	Computer Systems Engineering	
6.3730[J]	Statistics, Computation and Applications	
6.3900	Introduction to Machine Learning	
6.4120[J]	Computational Cognitive Science	
6.4400	Computer Graphics	
6.4530[J]	Principles and Practice of Assistive Technology	
6.5151	Large-scale Symbolic Systems	
6.5831	Database Systems	
6.8301	Advances in Computer Vision	
6.8371	Digital and Computational Photography	
6.8611	Quantitative Methods for Natural Language Processing	
6.8701	Computational Biology: Genomes, Networks, Evolution	
6.8711[J]	Computational Systems Biology: Deep Learning in the Life Sciences	
18.404	Theory of Computation	
Algorithms-intensive		
6.1220[J]	Design and Analysis of Algorithms	
Software-intensive		
6.1020	Software Construction	
6.1040	Software Design	
6.1060	Software Performance Engineering	
6.1100	Computer Language Engineering	
6.1920	Constructive Computer Architecture	
6.4200[J]	Robotics: Science and Systems	
6.4550[J]	Interactive Music Systems	
6.5081	Multicore Programming	

Inquiries

Additional information about the department's undergraduate programs may be obtained from the EECS Undergraduate Office (*ug@eecs.mit.edu*), Room 38-476, 617-253-7329.

Graduate Study

Master of Engineering

The Department of Electrical Engineering and Computer Science permits qualified MIT undergraduate students to apply for one of three Master of Engineering (MEng) programs. These programs consist of an additional, fifth year of study beyond one of the Bachelor of Science programs offered by the department.

Recipients of a Master of Engineering degree normally receive a Bachelor of Science degree simultaneously. No thesis is explicitly required for the Bachelor of Science degree. However, every program must include a major project experience at an advanced level, culminating in written and oral reports.

The Master of Engineering degree also requires completion of 24 units of thesis credit under 6.THM Master of Engineering Program Thesis. While a student may register for more than this number of thesis units, only 24 units count toward the degree requirement. Adjustments to the department requirements are made on an individual basis when it is clear that a student would be better served by a variation in the requirements because of their strong prior background.

Programs leading to the five-year Master of Engineering degree or to the 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 may apply to continue through the five-year master's program. 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's level experience in EECS at MIT should see the Master of Science program described later in this section.

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.

Four MEng programs are available:

- The Master of Engineering in Electrical Engineering and Computer Science (6-P) program is intended to provide the depth of knowledge and the skills needed for advanced graduate study and for professional work, as well as the breadth and perspective essential for engineering leadership in an increasingly complex technological world.

- The 6-A Master of Engineering Thesis Program with Industry combines the Master of Engineering academic program with periods of industrial practice at affiliated companies. An undergraduate wishing to pursue this degree should initially register for one of the department's three bachelor's programs.
- The Department of Electrical Engineering and Computer Science jointly offers a Master of Engineering in Computer Science and Molecular Biology (6-7P) with the Department of Biology (Course 7). This program is modeled on the 6-P program, but provides additional depth in computational biology through coursework and a substantial thesis.
- The Department of Electrical Engineering and Computer Science jointly offers a Master of Engineering in Computation and Cognition (6-9P) with the Department of Brain and Cognitive Sciences (Course 9). This program builds on the Bachelor of Science in Computation and Cognition, providing additional depth in the subject areas through advanced coursework and a substantial thesis.

Master of Engineering in Electrical Engineering and Computer Science (Course 6-P)

Through a seamless, five-year course of study, the Master of Engineering in Electrical Engineering and Computer Science (6-P) (*http://catalog.mit.edu/degree-charts/master-electrical-engineering-computer-science-course-6-p*) program leads directly to the simultaneous awarding of the Master of Engineering and one of the three bachelor's degrees offered by the department. The 6-P program is intended to provide the skills and depth of knowledge in a selected field of concentration 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 student selects 42 units from a list of subjects approved by the Graduate Office; 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.

Master of Engineering Thesis Program with Industry (Course 6-A)

The 6-A Master of Engineering Thesis Program with Industry (*http://vi-a.mit.edu*) 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 apply for admission to 6-PA, which is the 6-A version of the department's five-year 6-P Master of Engineering degree program. 6-PA students do their Master of Engineering thesis at their participating company's facilities. They can apply up to 24 units of work-assignment credit toward their Master of Engineering degree. 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 program is available at the 6-A Office, Room 38-409E, 617-253-4644.

Master of Engineering in Computer Science and Molecular Biology (Course 6-7P)

The Departments of Biology and Electrical Engineering and Computer Science jointly offer a Master of Engineering in Computer Science and Molecular Biology (6-7P) (*http://catalog.mit.edu/degree-charts/master-computer-science-molecular-biology-course-6-7p*). A detailed description of the program (*http://catalog.mit.edu/interdisciplinary/graduate-programs/computer-science-molecular-biology*) requirements may be found under the section on Interdisciplinary Programs.

Master of Engineering in Computation and Cognition (Course 6-9P)

The Departments of Brain and Cognitive Sciences and Electrical Engineering and Computer Science jointly offer a Master of Engineering in Computation and Cognition (6-9P) (*http://catalog.mit.edu/degree-charts/master-computation-cognition-course-6-9p*). A detailed description of the program (*http://catalog.mit.edu/interdisciplinary/graduate-programs/computation-*

cognition) requirements may be found under the section on Interdisciplinary Programs.

Master of Computer Science, Economics, and Data Science (Course 6-14P)

The Department of Electrical Engineering and Computer Science and the Department of Economics jointly offer a Master of Engineering in Computer Science, Economics, and Data Science (6-14P). A detailed description of the program requirements (*http://catalog.mit.edu/interdisciplinary/graduate-programs/computer-science-economics-data-science*) can be found in the Interdisciplinary Programs section.

Predoctoral and Doctoral 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, Brain and Cognitive Sciences, Economics, Linguistics and Philosophy, Management, Mathematics, and Physics.

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, Laboratory for Energy and the Environment (see MIT Energy Initiative), Kavli Institute for Astrophysics and Space Research, Lincoln Laboratory, Materials Research Laboratory, MIT Media Lab, Francis Bitter Magnet Laboratory, Operations Research Center, Plasma Science and Fusion Center, and the Microsystems Technology Laboratories. Descriptions of many of these laboratories (*http://catalog.mit.edu/mit/research*) may be found under the section on Research and Study.

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 (*http://catalog.mit.edu/mit/graduate-education/general-degree-requirements*) are listed under Graduate Education. The department requires that the 66-unit program consist of at least four subjects from a list of approved subjects by the Graduate Office which must include a minimum of 42 units of advanced graduate subjects. In addition, a 24-unit thesis is required beyond the 66 units. Students working full-time for the Master of Science degree may take as many as four classroom subjects per term. The subjects are wholly elective and are not restricted to those given by the department. The program of study must be well balanced, emphasizing one or more of the theoretical or experimental aspects of electrical engineering or computer science.

Electrical Engineer or Engineer in Computer Science
The general requirements for an engineer's degree (*http://catalog.mit.edu/mit/graduate-education/general-degree-requirements*) are given under the section on Graduate Education. 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 from a list of subjects approved by the Graduate Office, 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 (*http://catalog.mit.edu/mit/graduate-education/general-degree-requirements*) are given under the section on Graduate Education. 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 research centers described in the Research and Study (*http://catalog.mit.edu/mit/research*) section, such as the Operations Research Center.

Financial Support

Master of Engineering Degree Students
Students in the fifth year of study toward the Master of Engineering degree are commonly supported by a graduate teaching or research assistantship. In the 6-A Master of Engineering Thesis Program with Industry, students are supported by paid company internships. Students supported by full-time research or teaching assistantships may register for no more than two regular classes totaling at most 27 units. They receive additional academic units for their participation in the teaching or research 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 may not be available for all of those admitted to the Master of Engineering program. The MEng degree is normally completed by students taking a full load of regular subjects in two graduate terms. Students receiving assistantships commonly require a third term and may petition to continue for a fourth graduate term.

Master of Science, Engineer, and Doctoral Degree Students
Studies toward an advanced degree can be supported by personal funds, by an award such as the National Science Foundation Fellowship (which the student brings to MIT), by a fellowship or traineeship awarded by MIT, or by a graduate assistantship. Assistantships require participation in research or teaching in the department or in one of the associated laboratories. Full-time assistants may register for no more than two scheduled classroom or laboratory subjects during the term, but may receive additional academic credit for their participation in the teaching or research program.

Inquiries
Additional information concerning graduate academic and research programs, admissions, financial aid, and assistantships may be obtained from the Electrical Engineering and Computer Science Graduate Office, Room 38-444, 617-253-4605, or visit the EECS website (*http://www.eecs.mit.edu*).

Interdisciplinary Programs

Computational Science and Engineering
The Master of Science in Computational Science and Engineering (CSE SM) (*https://cse.mit.edu/programs/sm*) is an interdisciplinary program that provides students with a strong foundation in computational methods for applications in science and engineering. The CSE SM program trains students in the formulation, analysis, implementation, and application of computational approaches via a common core, which serves all science and engineering disciplines, and an elective component which focuses on particular disciplinary applications. The program emphasizes:

- Breadth through introductory courses in numerical analysis, simulation, and optimization
- Depth in the student’s chosen field
- Multidisciplinary aspects of computation
- Hands-on experience through projects, assignments, and a master's thesis

Current MIT graduate students may pursue a CSE SM in conjunction with a department-based master's or PhD program.

For more information, see the full program description (*http://catalog.mit.edu/interdisciplinary/graduate-programs/computational-science-engineering*) under Interdisciplinary Graduate Programs.

Joint Program with the Woods Hole Oceanographic Institution
The Joint Program with the Woods Hole Oceanographic Institution (WHOI) (*http://mit.whoi.edu*) is intended for students whose primary career objective is oceanography or 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; 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 their home department. The program is described in more detail (*http://catalog.mit.edu/interdisciplinary/graduate-programs/joint-program-woods-hole-oceanographic-institution*) under Interdisciplinary Graduate Programs.

Leaders for Global Operations
The 24-month Leaders for Global Operations (LGO) (*http://catalog.mit.edu/interdisciplinary/graduate-programs/leaders-global-operations*) program combines graduate degrees in engineering and management for those with previous postgraduate work experience and strong undergraduate degrees in a technical field. During the two-year program, students complete a six-month internship at one of LGO's partner companies, where they conduct research that forms the basis of a dual-degree thesis. Students finish the program with two MIT degrees: an MBA (or SM in management) and an SM from one of seven engineering programs, some of which have optional or required LGO tracks. After graduation, alumni lead strategic initiatives in high-tech, operations, and manufacturing companies.

System Design and Management
The System Design and Management (SDM) (*http://sdm.mit.edu*) 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.

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) (*http://tpp.mit.edu*) 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, quantitative methods, and social science. 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. See the program description (*http://catalog.mit.edu/schools/mit-schwarzman-college-computing/data-systems-society*) under the Institute for Data, Systems, and Society.

Faculty and Teaching Staff

Asuman E. Ozdaglar, PhD
MathWorks Professor of Electrical Engineering and Computer Science
Head, Department of Electrical Engineering and Computer Science
Professor of Electrical Engineering
Deputy Dean of Academics, MIT Schwarzman College of Computing
Member, Institute for Data, Systems, and Society

Arvind Mithal, PhD
Charles W. and Jennifer C. Johnson Professor in Electrical Engineering and Computer Science
Professor of Computer Science and Engineering
Faculty Head, Computer Science, Department of Electrical Engineering and Computer Science

Antonio Torralba, PhD
Delta Electronics Professor
Professor of Electrical Engineering and Computer Science
Faculty Head, Artificial Intelligence and Decision-Making Department of Electrical Engineering and Computer Science

Joel Voldman, PhD
William R. Brody (1965) Professor
Professor of Electrical Engineering
Faculty Head, Electrical Engineering, Department of Electrical Engineering and Computer Science

Professors
Harold Abelson, PhD
Class of 1992 Professor
Professor of Electrical Engineering and Computer Science

Elfar Adalsteinsson, PhD
Eaton-Peabody Professor
Professor of Electrical Engineering
Core Faculty, Institute for Medical Engineering and Science

Anant Agarwal, PhD
Professor of Electrical Engineering and Computer Science

Akintunde I. Akinwande, PhD
Thomas and Gerd Perkins Professor of Electrical Engineering and Computer Science
Professor of Electrical Engineering

Saman P. Amarasinghe, PhD
Professor of Computer Science and Engineering

Hari Balakrishnan, PhD
Fujitsu Professor in Electrical Engineering and Computer Science
Professor of Electrical Engineering and Computer Science
(On leave)

Marc A. Baldo, PhD
Dugald C. Jackson Professor in Electrical Engineering
Professor of Electrical Engineering

Regina Barzilay, PhD
School of Engineering Distinguished Professor for AI and Health
Professor of Electrical Engineering and Computer Science
Affiliate Faculty, Institute for Medical Engineering and Science

Karl K. Berggren, PhD
Joseph F. and Nancy P. Keithley Professor in Electrical Engineering
Professor of Electrical Engineering

Dimitri P. Bertsekas, PhD
Jerry McAfee (1940) Professor Post-Tenure in Engineering
Professor Post-Tenure of Electrical Engineering
Member, Institute for Data, Systems, and Society

Robert C. Berwick, PhD
Professor of Computer Science and Engineering and Computational Linguistics
Member, Institute for Data, Systems, and Society
(On leave)

Sangeeta N. Bhatia, MD, PhD
John J. and Dorothy Wilson Professor of Health Sciences and Technology and Electrical Engineering and Computer Science
Professor of Electrical Engineering and Computer Science
Core Faculty, Institute for Medical Engineering and Science

Duane S. Boning, PhD
Clarence J. LeBel Professor in Electrical Engineering and Computer Science
Professor of Electrical Engineering

Vladimir Bulović, PhD
Fariborz Maseeh (1990) Professor in Emerging Technology
Professor of Electrical Engineering

Vincent W. S. Chan, PhD
Joan and Irwin M. (1957) Jacobs Professor Post-Tenure
Professor Post-Tenure of Electrical Engineering

Anantha P. Chandrakasan, PhD
Vannevar Bush Professor
Professor of Electrical Engineering and Computer Science
Dean, School of Engineering

Adam Chlipala, PhD
Professor of Electrical Engineering and Computer Science
(On leave, fall)

Isaac Chuang, PhD
Professor of Electrical Engineering
Professor of Physics

Munther A. Dahleh, PhD
William A. Coolidge Professor
Professor of Electrical Engineering and Computer Science
Member, Institute for Data, Systems, and Society
(On leave, fall)

Luca Daniel, PhD
Professor of Electrical Engineering and Computer Science

Konstantinos Daskalakis, PhD
Armen Avanessians (1982) Professor
Professor of Electrical Engineering and Computer Science

Randall Davis, PhD
Professor of Computer Science and Engineering

Jesús A. del Alamo, PhD
Donner Professor of Science
Professor of Electrical Engineering

Erik D. Demaine, PhD
Professor of Computer Science and Engineering

Srinivas Devadas, PhD
Edwin Sibley Webster Professor
Professor of Electrical Engineering
(On leave)

Frederic Durand, PhD
Amar Bose Professor of Computing
Professor of Computer Science and Engineering
(On leave)

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Henry Ellis Warren (1894) Professor
Professor of Electrical Engineering
Member, Health Sciences and Technology Faculty

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Professor Post-Tenure of Electrical Engineering and Computer Science

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Elihu Thomson Professor in Electrical Engineering
Professor of Electrical Engineering

David K. Gifford, PhD
Professor Post-Tenure of Computer Science and Engineering

Shafrira Goldwasser, PhD
RSA Professor Post-Tenure
Professor Post-Tenure of Computer Science and Engineering

Polina Golland, PhD
Sunlin (1966) and Priscilla Chou Professor
Professor of Computer Science and Engineering
Member, Institute for Data, Systems, and Society

Martha L. Gray, PhD
Whitaker Professor in Biomedical Engineering
Professor of Electrical Engineering and Computer Science
Member, Health Sciences and Technology Faculty
Core Faculty, Institute for Medical Engineering and Science
(On leave)

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Chancellor for Academic Advancement

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Dugald C. Jackson Professor in Electrical Engineering
Professor of Electrical Engineering and Computer Science

Jongyoon Han, PhD
Professor of Electrical Engineering
Professor of Biological Engineering

Berthold Klaus Paul Horn, PhD
Professor Post-Tenure of Computer Science and Engineering

Qing Hu, PhD
Distinguished Professor in Electrical Engineering and Computer Science
Professor of Electrical Engineering
(On leave, spring)

Daniel Huttenlocher, PhD
Henry Ellis Warren (1894) Professor
Professor of Electrical Engineering and Computer Science
Dean, MIT Schwarzman College of Computing

Piotr Indyk, PhD
Thomas D. and Virginia W. Cabot Professor
Professor of Electrical Engineering and Computer Science
(On leave, fall)

Tommi S. Jaakkola, PhD
Thomas M. Siebel Distinguished Professor
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Professor of Electrical Engineering and Computer Science
Professor of Civil and Environmental Engineering
Member, Institute for Data, Systems, and Society
(On leave, fall)

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Charles A. Piper (1935) Professor
Professor of Electrical Engineering and Computer Science

Leslie P. Kaelbling, PhD
Panasonic Professor
Professor of Computer Science and Engineering
(On leave, spring)

David R. Karger, PhD
Professor of Computer Science and Engineering
(On leave)

Dina Katabi, PhD
Thuan (1990) and Nicole Pham Professor
Professor of Electrical Engineering and Computer Science

Manolis Kellis, PhD
Professor of Computer Science

James L. Kirtley Jr, PhD
Professor Post-Tenure of Electrical Engineering

Leslie A. Kolodziejski, PhD
Professor of Electrical Engineering

Jing Kong, PhD
Professor of Electrical Engineering
(On leave, fall)

Jeffrey H. Lang, PhD
Vitesse Professor
Professor of Electrical Engineering

Hae-Seung Lee, PhD
Advanced Television and Signal Processing (ATSP) Professor
Professor of Electrical Engineering
(On leave, fall)

Steven B. Leeb, PhD
Emanuel Landsman (1958) Professor
Professor of Electrical Engineering
Professor of Mechanical Engineering

Charles E. Leiserson, PhD
Edwin Sibley Webster Professor
Professor of Electrical Engineering

Jae S. Lim, PhD
Professor Post-Tenure of Electrical Engineering

Tomás Lozano-Pérez, PhD
School of Engineering Professor of Teaching Excellence
Professor of Electrical Engineering and Computer Science
(On leave)

Nancy Ann Lynch, PhD
NEC Professor Post-Tenure of Software Science and Engineering
Professor Post-Tenure of Electrical Engineering and Computer Science

Samuel R. Madden, PhD
Distinguished College of Computing Professor
Professor of Computer Science and Engineering

Aleksander Madry, PhD
Cadence Design Systems Professor
Professor of Computer Science
(On leave)

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Institute Professor
Professor of Operations Research
Professor of Electrical Engineering

Wojciech Matusik, PhD
Professor of Electrical Engineering and Computer Science

Muriel Médard, ScD
NEC Professor of Software Science and Engineering
Professor of Electrical Engineering and Computer Science
(On leave)

Alexandre Megretski, PhD
Professor of Electrical Engineering
Member, Institute for Data, Systems, and Society

Silvio Micali, PhD
Ford Foundation Professor Post-Tenure of Engineering
Professor Post-Tenure of Computer Science and Engineering

Robert C. Miller, PhD
Distinguished Professor of Electrical Engineering and Computer Science
Professor of Computer Science and Engineering

Robert T. Morris, PhD
Professor of Computer Science and Engineering

William D. Oliver, PhD
Henry Ellis Warren (1894) Professor
Professor of Electrical Engineering and Computer Science

Alan V. Oppenheim, PhD
Ford Foundation Professor Post-Tenure of Engineering
Professor Post-Tenure of Electrical Engineering and Computer Science

Terry Philip Orlando, PhD
Professor Post-Tenure of Electrical Engineering

Tomás Palacios, PhD
Clarence J. Lebel Professor in Electrical Engineering
Professor of Electrical Engineering

Pablo A. Parrilo, PhD
Joseph F. and Nancy P. Keithley Professor in Electrical Engineering
Professor of Electrical Engineering and Computer Science
Professor of Mathematics
Member, Institute for Data, Systems, and Society

David J. Perreault, PhD
Ford Foundation Professor of Engineering
Professor of Electrical Engineering and Computer Science

Yury Polyanskiy, PhD
Professor of Electrical Engineering and Computer Science
Member, Institute for Data, Systems, and Society

Rajeev J. Ram, PhD
Professor of Electrical Engineering
(On leave)

L. Rafael Reif, PhD
Ray and Maria Stata Professor of Electrical Engineering and Computer Science
Professor of Electrical Engineering
President Emeritus
(On leave)

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

Ronitt Rubinfeld, PhD
Edwin Sibley Webster Professor
Professor of Computer Science and Engineering
(On leave)

Daniela L. Rus, PhD
Andrew (1956) and Erna Viterbi Professor
Professor of Computer Science and Engineering
Deputy Dean of Research, MIT Schwarzman College of Computing

Daniel Sánchez Martín, PhD
Professor of Electrical Engineering and Computer Science

Martin A. Schmidt, PhD
Ray and Maria Stata Professor
Professor of Electrical Engineering and Computer Science
(On leave)

Devavrat Shah, PhD
Andrew (1956) and Erna Viterbi Professor
Professor of Electrical Engineering and Computer Science
Member, Institute for Data, Systems, and Society
(On leave)

Jeffrey H. Shapiro, PhD
Julius A. Stratton Professor Post-Tenure in Electrical Engineering and Physics
Professor Post-Tenure of Electrical Engineering

Nir N. Shavit, PhD
Professor of Electrical Engineering and Computer Science

Charles G. Sodini, PhD
Clarence J. LeBel Professor Post-Tenure in Electrical Engineering
Professor Post-Tenure of Electrical Engineering
Core Faculty, Institute for Medical Engineering and Science

Armando Solar Lezama, PhD
Distinguished College of Computing Professor
Professor of Electrical Engineering and Computer Science

David A. Sontag, PhD
Hermann L. F. von Helmholtz Professor
Professor of Electrical Engineering and Computer Science
Core Faculty, Institute for Medical Engineering and Science
(On leave, fall)

Collin M. Stultz, MD, PhD
Nina T. and Robert H. Rubin Professor in Medical Engineering and Science
Professor of Electrical Engineering and Computer Science
Core Faculty, Institute for Medical Engineering and Science
Co-Director, Health Sciences and Technology Program

Gerald Jay Sussman, PhD
Panasonic Professor
Professor of Electrical Engineering

Peter Szolovits, PhD
Professor of Computer Science and Engineering
Core Faculty, Institute for Medical Engineering and Science

Russell L. Tedrake, PhD
Toyota Professor
Professor of Computer Science and Engineering
Professor of Aeronautics and Astronautics
Professor of Mechanical Engineering

Bruce Tidor, PhD
Professor of Electrical Engineering and Computer Science
Professor of Biological Engineering

John N. Tsitsiklis, PhD
Clarence J. LeBel Professor in Electrical Engineering and Computer Science
Professor Post-Tenure of Electrical Engineering
Member, Institute for Data, Systems, and Society

Caroline Uhler, PhD
Professor of Electrical Engineering and Computer Science
Member, Institute for Data, Systems, and Society

Vinod Vaikuntanathan, PhD
Professor of Electrical Engineering and Computer Science

George C. Verghese, PhD
Henry Ellis Warren (1894) Professor Post-Tenure
Professor Post-Tenure of Electrical and Biomedical Engineering

Martin J. Wainwright, PhD
Cecil H. Green Professor in Electrical Engineering
Professor of Electrical Engineering and Computer Science
Professor of Mathematics
Member, Institute for Data, Systems, and Society

Cardinal Warde, PhD
Professor of Electrical Engineering

Jacob K. White, PhD
Cecil H. Green Professor in Electrical Engineering
Professor of Electrical Engineering
(On leave, spring)

Richard Ryan Williams, PhD
Professor of Electrical Engineering and Computer Science

Virginia Williams, PhD
Professor of Electrical Engineering and Computer Science
(On leave, fall)

Gregory W. Wornell, PhD
Sumitomo Electric Industries Professor in Engineering
Professor of Electrical Engineering
Member, Institute for Data, Systems, and Society

Nickolai Zeldovich, PhD
Professor of Electrical Engineering and Computer Science

Lizhong Zheng, PhD
Professor of Electrical Engineering

Victor Waito Zue, ScD
Delta Electronics Professor Post-Tenure
Professor Post-Tenure of Electrical Engineering and Computer Science

Associate Professors

Fadel Adib, PhD
Associate Professor of Media Arts and Sciences
Associate Professor of Electrical Engineering and Computer Science

Mohammadreza Alizadeh Attar, PhD
Associate Professor of Electrical Engineering and Computer Science

Jacob Andreas, PhD
Associate Professor of Electrical Engineering and Computer Science

Adam M. Belay, PhD
Associate Professor of Electrical Engineering and Computer Science

Guy Bresler, PhD
Associate Professor of Electrical Engineering and Computer Science
Member, Institute for Data, Systems, and Society
(On leave)

Tamara A. Broderick, PhD
Associate Professor of Electrical Engineering and Computer Science
Member, Institute for Data, Systems, and Society
(On leave)

Michael J. Carbin, PhD
Associate Professor of Electrical Engineering and Computer Science
(On leave)

Christina Delimitrou, PhD
Associate Professor of Electrical Engineering and Computer Science

Dirk R. Englund, PhD
Associate Professor of Electrical Engineering and Computer Science

Mohsen Ghaffari, PhD
Associate Professor of Electrical Engineering and Computer Science
(On leave, fall)

Manya Ghobadi, PhD
Associate Professor of Electrical Engineering and Computer Science

Peter L. Hagelstein, PhD
Associate Professor of Electrical Engineering

Ruonan Han, PhD
Associate Professor of Electrical Engineering and Computer Science

Song Han, PhD
Associate Professor of Electrical Engineering and Computer Science
(On leave, spring)

Thomas Heldt, PhD
Associate Professor of Electrical Engineering and Computer Science
Core Faculty, Institute for Medical Engineering and Science

Phillip John Isola, PhD
Class of 1948 Career Development Professor
Associate Professor of Electrical Engineering and Computer Science

Stefanie Sabrina Jegelka, ScD
Associate Professor of Electrical Engineering and Computer Science
Member, Institute for Data, Systems, and Society
(On leave)

Tim Kraska, PhD
Associate Professor of Electrical Engineering and Computer Science

Laura D. Lewis, PhD
Athinoula A. Martinos Associate Professor
Associate Professor of Electrical Engineering and Computer Science
Core Faculty, Institute for Medical Engineering and Science

Luqiao Liu, PhD
Associate Professor of Electrical Engineering and Computer Science

Stefanie Mueller, PhD
TIBCO Founders Professor
Associate Professor of Electrical Engineering and Computer Science
Associate Professor of Mechanical Engineering

Kevin O'Brien, PhD
Associate Professor of Electrical Engineering and Computer Science

Jonathan M. Ragan-Kelley, PhD
Associate Professor of Electrical Engineering and Computer Science

Arvind Satyanarayan, PhD
Associate Professor of Electrical Engineering and Computer Science

Julian Shun, PhD
Associate Professor of Electrical Engineering and Computer Science

Justin Solomon, PhD
Associate Professor of Electrical Engineering and Computer Science

Suvrit Sra, PhD
Associate Professor of Electrical Engineering and Computer Science
Member, Institute for Data, Systems, and Society

Vivienne Sze, PhD
Associate Professor of Electrical Engineering and Computer Science

Assistant Professors

Pulkit Agrawal, PhD
Assistant Professor of Electrical Engineering and Computer Science

Sara Beery, PhD
Assistant Professor of Electrical Engineering and Computer Science

YuFeng Chen, PhD
Assistant Professor of Electrical Engineering and Computer Science

Samantha Coday, PhD
Assistant Professor of Electrical Engineering and Computer Science

Connor W. Coley, PhD
Class of 1957 Career Development Professor
Assistant Professor of Chemical Engineering
Assistant Professor of Electrical Engineering and Computer Science

Henry Corrigan-Gibbs, PhD
Douglas Ross (1954) Career Development Professor of Software Technology
Assistant Professor of Electrical Engineering and Computer Science

Priya Donti, PhD
Assistant Professor of Electrical Engineering and Computer Science

Gabriele Farina, PhD
Assistant Professor of Electrical Engineering and Computer Science

Marzyeh Ghassemi, PhD
Herman L. F. von Helmholtz Career Development Professor
Assistant Professor of Electrical Engineering and Computer Science
Core Faculty, Institute for Medical Engineering and Science
(On leave)

Dylan J. Hadfield-Menell, PhD
Bonnie and Marty (1964) Tenenbaum Career Development Professor
Assistant Professor of Electrical Engineering and Computer Science

Samuel B. Hopkins, PhD
Jamieson Career Development Professor in Electrical Engineering and Computer Science
Assistant Professor of Electrical Engineering and Computer Science

Ericmoore Jossou, PhD
John Clark Hardwick (1986) Professor
Assistant Professor of Nuclear Science and Engineering
Assistant Professor of Electrical Engineering and Computer Science

Yoon Kim, PhD
NBX Professor
Assistant Professor of Electrical Engineering and Computer Science

Mina Konakovic Lukovic, PhD
Assistant Professor of Electrical Engineering and Computer Science

Kuikui Liu, PhD
Assistant Professor of Electrical Engineering and Computer Science

Anand Venkat Natarajan, PhD
ITT Career Development Professor in Computer Technology
Assistant Professor of Electrical Engineering and Computer Science

Farnaz Niroui, PhD
Assistant Professor of Electrical Engineering and Computer Science

Jelena Notaros, PhD
Robert J. Shillman (1974) Career Development Professor in EECS
Assistant Professor of Electrical Engineering and Computer Science

Manish Raghavan, PhD
Drew Houston (2005) Career Development Professor
Assistant Professor of Electrical Engineering and Computer Science
Assistant Professor of Information Technology

Negar Reiskarimian, PhD
Assistant Professor of Electrical Engineering and Computer Science

Nidhi Seethapathi, PhD
Assistant Professor of Brain and Cognitive Sciences
Assistant Professor of Electrical Engineering and Computer Science

Vincent Sitzmann, PhD
Assistant Professor of Electrical Engineering and Computer Science

Tess E. Smidt, PhD
X-Window Consortium Professor
Assistant Professor of Electrical Engineering and Computer Science

Ashia Wilson, PhD
Lister Brothers (Gordon K. '30 and Donald K. '34) Professor
Assistant Professor of Electrical Engineering and Computer Science

Mengjia Yan, PhD
Homer A. Burnell Career Development Professor
Assistant Professor of Electrical Engineering and Computer Science

Guangyu Robert Yang, PhD
Assistant Professor of Brain and Cognitive Sciences
Assistant Professor of Electrical Engineering and Computer Science

Sixian You, PhD
Alfred Henry (1929) and Jean Morrison Hayes Career Development Professor
Assistant Professor of Electrical Engineering and Computer Science

Professors of the Practice

Ahmad Bahai, PhD
Professor of the Practice of Electrical Engineering and Computer Science

Joel S. Emer, PhD
Professor of the Practice of Electrical Engineering and Computer Science

Adjunct Professors

David J. DeWitt, PhD
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Marija Ilic, PhD
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Butler W. Lampson, PhD
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Michael Stonebraker, PhD
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Adjunct Associate Professor of Electrical Engineering and Computer Science

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Ana Bell, PhD
Senior Lecturer in Electrical Engineering and Computer Science

Tony Eng, PhD
Senior Lecturer in Electrical Engineering and Computer Science

Adam J. Hartz, MEng
Senior Lecturer in Electrical Engineering and Computer Science

Katrina Leigh LaCurts, PhD
Senior Lecturer in Electrical Engineering and Computer Science

Joseph Daly Steinmeyer, PhD
Senior Lecturer in Electrical Engineering and Computer Science

Lecturers
Zachary R. Abel, PhD
Lecturer in Electrical Engineering and Computer Science

Brynmor Chapman, PhD
Lecturer in Electrical Engineering and Computer Science

Silvina Z. Hanono Wachman, PhD
Principal Lecturer in Electrical Engineering and Computer Science

Mauricio Karchmer, PhD
Lecturer in Electrical Engineering and Computer Science

Kyle Keane, PhD
Lecturer in Electrical Engineering and Computer Science

Kimberle Koile, PhD
Principal Lecturer in Electrical Engineering and Computer Science

Vincent J. Monardo, PhD
Lecturer in Electrical Engineering and Computer Science

Srinivasan Raghuraman, PhD
Lecturer in Electrical Engineering and Computer Science

Shen Shen, PhD
Lecturer in Electrical Engineering and Computer Science

Christopher W. Tanner, MS
Lecturer in Electrical Engineering and Computer Science

Andrew Wang, PhD
Lecturer in Electrical Engineering and Computer Science

Technical Instructors
David L. Lewis, AA
Technical Instructor of Electrical Engineering and Computer Science

Anthony Pennes, SB
Technical Instructor of Electrical Engineering and Computer Science

Alexander D. Reduker, SB
Technical Instructor of Electrical Engineering and Computer Science

Research Staff

Visiting Scholars
Alfred Z. Spector, PhD
Visiting Scholar of Electrical Engineering and Computer Science

Professors Emeriti

Dimitri A. Antoniadis, PhD
Ray and Maria Stata Professor Emeritus
Professor Emeritus of Electrical Engineering

Arthur B. Baggeroer, ScD
Professor Emeritus of Mechanical and Ocean Engineering
Professor Emeritus of Electrical Engineering

Tim Berners-Lee, BA
3 Com Founders Professor Emeritus of Engineering

Rodney A. Brooks, PhD
Professor Emeritus of Computer Science and Engineering

James Donald Bruce, ScD
Professor Emeritus of Electrical Engineering

Jack B. Dennis, ScD
Professor Emeritus of Computer Science and Engineering

Clifton G. Fonstad Jr, PhD
Vitesse Professor Emeritus
Professor Emeritus of Electrical Engineering

G. David Forney, ScD
Adjunct Professor Emeritus of Electrical Engineering

Robert G. Gallager, ScD
Professor Emeritus of Electrical Engineering

Alan J. Grodzinsky, ScD
Professor Emeritus of Biological Engineering
Professor Emeritus of Electrical Engineering
Professor Emeritus of Mechanical Engineering

Frederick C. Hennie III, PhD
Professor Emeritus of Computer Science and Engineering

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

John G. Kassakian, ScD
Professor Emeritus of Electrical Engineering

Francis Fan Lee, PhD
Professor Emeritus of Electrical Engineering and Computer Science

Barbara H. Liskov, PhD
Institute Professor Emerita
Professor Emerita of Computer Science

Albert R. Meyer, PhD
Hitachi America Professor Emeritus
Professor Emeritus of Computer Science and Engineering

Ronald R. Parker, PhD
Professor Emeritus of Nuclear Science and Engineering
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Ronald L. Rivest, PhD
Institute Professor Emeritus
Professor Emeritus of Computer Science and Engineering

Jerome H. Saltzer, ScD
Professor Emeritus of Computer Science and Engineering

Herbert Harold Sawin, PhD
Professor Emeritus of Chemical Engineering
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Joel E. Schindall, PhD
Bernard M. Gordon Professor of the Practice Emeritus

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Professor Emeritus of Electrical Engineering

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Alan S. Willsky, PhD
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Professor Emeritus of Electrical Engineering and Computer Science

Gerald L. Wilson, PhD
Vannevar Bush Professor Emeritus
Professor Emeritus of Electrical Engineering
Professor Emeritus of Mechanical Engineering

Programming & Software Engineering

6.100A Introduction to Computer Science Programming in Python
Prereq: None
U (Fall, Spring; first half of term)
3-0-3 units
Credit cannot also be received for 6.100L

Introduction to computer science and programming for students with little or no programming experience. Students develop skills to program and use computational techniques to solve problems. Topics include the notion of computation, Python, simple algorithms and data structures, testing and debugging, and algorithmic complexity. Combination of 6.100A and 6.100B or 16.C20[J] counts as REST subject. Final given in the seventh week of the term.
A. Bell, J. V. Guttag

6.100B Introduction to Computational Thinking and Data Science
Prereq: 6.100A or permission of instructor
U (Fall, Spring; second half of term)
3-0-3 units
Credit cannot also be received for 9.C20[J], 16.C20[J], 18.C20[J], CSE.C20[J]

Provides an introduction to using computation to understand real-world phenomena. Topics include plotting, stochastic programs, probability and statistics, random walks, Monte Carlo simulations, modeling data, optimization problems, and clustering. Combination of 6.100A and 6.100B counts as REST subject.
A. Bell, J. V. Guttag

6.100L Introduction to Computer Science and Programming
Prereq: None
U (Fall, Spring)
3-0-6 units
Credit cannot also be received for 6.100A

Introduction to computer science and programming for students with no programming experience. Presents content taught in 6.100A over an entire semester. Students develop skills to program and use computational techniques to solve problems. Topics include the notion of computation, Python, simple algorithms and data structures, testing and debugging, and algorithmic complexity.
A. Bell, J. V. Guttag

6.1010 Fundamentals of Programming
Prereq: 6.100A
U (Fall, Spring)
2-4-6 units. Institute LAB

Introduces fundamental concepts of programming. Designed to develop skills in applying basic methods from programming languages to abstract problems. Topics include programming and Python basics, computational concepts, software engineering, algorithmic techniques, data types, and recursion. Lab component consists of software design, construction, and implementation of design. Enrollment may be limited.
D. S. Boning, A. Chlipala, S. Devadas, A. Hartz

6.1020 Software Construction
Prereq: 6.1010
U (Spring)
3-0-12 units

Introduces fundamental principles and techniques of software development: how to write software that is safe from bugs, easy to understand, and ready for change. Topics include specifications and invariants; testing, test-case generation, and coverage; abstract data types and representation independence; design patterns for object-oriented programming; concurrent programming, including message passing and shared memory concurrency, and defending against races and deadlock; and functional programming with immutable data and higher-order functions. Includes weekly programming exercises and larger group programming projects.
M. Goldman, R. C. Miller

6.1040 Software Design
Prereq: 6.1020 and 6.1200[J]
U (Fall)
4-0-14 units

Provides design-focused instruction on how to build complex software applications. Design topics include classic human-computer interaction (HCI) design tactics (need finding, heuristic evaluation, prototyping, user testing), conceptual design (inventing, modeling and evaluating constituent concepts), social and ethical implications, abstract data modeling, and visual design. Implementation topics include reactive front-ends, web services, and databases. Students work both on individual projects and a larger team project in which they design and build full-stack web applications.
D. N. Jackson, A. Satyanarayan

6.1060 Software Performance Engineering
Prereq: 6.1020, 6.1210, and 6.1910
U (Fall)
3-12-3 units

Project-based introduction to building efficient, high-performance and scalable software systems. Topics include performance analysis, algorithmic techniques for high performance, instruction-level optimizations, vectorization, cache and memory hierarchy optimization, and parallel programming.
S. Amarasinghe, C. E. Leiserson

6.5060 Algorithm Engineering
Prereq: 6.1060 and 6.1220[J]
G (Spring)
3-0-9 units

Covers the theory and practice of algorithms and data structures. Topics include models of computation, algorithm design and analysis, and performance engineering of algorithm implementations. Presents the design and implementation of sequential, parallel, cache-efficient, and external-memory algorithms. Illustrates many of the principles of algorithm engineering in the context of parallel algorithms and graph problems.
J. Shun

6.5080 Multicore Programming
Subject meets with 6.5081
Prereq: 6.1210
G (Spring)
4-0-8 units

Introduces principles and core techniques for programming multicore machines. Topics include locking, scalability, concurrent data structures, multiprocessor scheduling, load balancing, and state-of-the-art synchronization techniques, such as transactional memory. Includes sequence of programming assignments on a large multicore machine, culminating with the design of a highly concurrent application. Students taking graduate version complete additional assignments.
N. Shavit

6.5081 Multicore Programming
Subject meets with 6.5080
Prereq: 6.1210
U (Spring)
4-0-8 units

Introduces principles and core techniques for programming multicore machines. Topics include locking, scalability, concurrent data structures, multiprocessor scheduling, load balancing, and state-of-the-art synchronization techniques, such as transactional memory. Includes sequence of programming assignments on a large multicore machine, culminating with the design of a highly concurrent application. Students taking graduate version complete additional assignments.
N. Shavit

Programming Languages

6.1100 Computer Language Engineering
Prereq: 6.1020 and 6.1910
U (Spring)
4-4-4 units

Analyzes issues associated with the implementation of higher-level programming languages. Fundamental concepts, functions, and structures of compilers. The interaction of theory and practice. Using tools in building software. Includes a multi-person project on compiler design and implementation.
M. C. Rinard

6.1120 Dynamic Computer Language Engineering
Prereq: 6.1020 or 6.1910
U (Fall)
4-4-4 units

Studies the design and implementation of modern, dynamic programming languages. Topics include fundamental approaches for parsing, semantics and interpretation, virtual machines, garbage collection, just-in-time machine code generation, and optimization. Includes a semester-long, group project that delivers a virtual machine that spans all of these topics.
M. Carbin

6.5110 Foundations of Program Analysis
Prereq: 6.1100
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Fall)
3-0-9 units

Presents major principles and techniques for program analysis. Includes formal semantics, type systems and type-based program analysis, abstract interpretation and model checking and synthesis. Emphasis on Haskell and Ocaml, but no prior experience in these languages is assumed. Student assignments include implementing of techniques covered in class, including building simple verifiers.
A. Solar-Lezama

6.5120 Formal Reasoning About Programs
Prereq: 6.1020 and 6.1200[J]
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Spring)
3-0-9 units

Surveys techniques for rigorous mathematical reasoning about correctness of software, emphasizing commonalities across approaches. Introduces interactive computer theorem proving with the Coq proof assistant, which is used for all assignments, providing immediate feedback on soundness of logical arguments. Covers common program-proof techniques, including operational semantics, model checking, abstract interpretation, type systems, program logics, and their applications to functional, imperative, and concurrent programs. Develops a common conceptual framework based on invariants, abstraction, and modularity applied to state and labeled transition systems.
A. Chlipala

6.5150 Large-scale Symbolic Systems
Subject meets with 6.5151
Prereq: 6.4100 or permission of instructor
G (Spring)
3-0-9 units

Concepts and techniques for the design and implementation of large software systems that can be adapted to uses not anticipated by the designer. Applications include compilers, computer-algebra systems, deductive systems, and some artificial intelligence applications. Covers means for decoupling goals from strategy, mechanisms for implementing additive data-directed invocation, work with partially-specified entities, and how to manage multiple viewpoints. Topics include combinators, generic operations, pattern matching, pattern-directed invocation, rule systems, backtracking, dependencies, indeterminacy, memoization, constraint propagation, and incremental refinement. Students taking graduate version complete additional assignments.
G. J. Sussman

6.5151 Large-scale Symbolic Systems
Subject meets with 6.5150
Prereq: 6.4100 or permission of instructor
U (Spring)
3-0-9 units

Concepts and techniques for the design and implementation of large software systems that can be adapted to uses not anticipated by the designer. Applications include compilers, computer-algebra systems, deductive systems, and some artificial intelligence applications. Covers means for decoupling goals from strategy, mechanisms for implementing additive data-directed invocation, work with partially-specified entities, and how to manage multiple viewpoints. Topics include combinators, generic operations, pattern matching, pattern-directed invocation, rule systems, backtracking, dependencies, indeterminacy, memoization, constraint propagation, and incremental refinement. Students taking graduate version complete additional assignments.
G. J. Sussman

6.5160[J] Classical Mechanics: A Computational Approach
Same subject as 8.351[J], 12.620[J]
Prereq: Physics I (GIR), 18.03, and permission of instructor
G (Fall)
3-3-6 units

See description under subject 12.620[J].
J. Wisdom, G. J. Sussman

Theoretical Computer Science

6.1200[J] Mathematics for Computer Science
Same subject as 18.062[J]
Prereq: Calculus I (GIR)
U (Fall, Spring)
5-0-7 units. REST

Elementary discrete mathematics for science and engineering, with a focus on mathematical tools and proof techniques useful in computer science. Topics include logical notation, sets, relations, elementary graph theory, state machines and invariants, induction and proofs by contradiction, recurrences, asymptotic notation, elementary analysis of algorithms, elementary number theory and cryptography, permutations and combinations, counting tools, and discrete probability.
Z. R. Abel, F. T. Leighton, A. Moitra

6.120A Discrete Mathematics and Proof for Computer Science
Prereq: Calculus I (GIR)
U (Spring; second half of term)
3-0-3 units

Subset of elementary discrete mathematics for science and engineering useful in computer science. Topics may include logical notation, sets, done relations, elementary graph theory, state machines and invariants, induction and proofs by contradiction, recurrences, asymptotic notation, elementary analysis of algorithms, elementary number theory and cryptography, permutations and combinations, counting tools.
Staff

6.1210 Introduction to Algorithms
Prereq: 6.100A and (6.120A or 6.1200[J])
U (Fall, Spring)
5-0-7 units

Introduction to mathematical modeling of computational problems, as well as common algorithms, algorithmic paradigms, and data structures used to solve these problems. Emphasizes the relationship between algorithms and programming, and introduces basic performance measures and analysis techniques for these problems. Enrollment may be limited.
E. Demaine, S. Devadas

6.1220[J] Design and Analysis of Algorithms
Same subject as 18.410[J]
Prereq: 6.1200[J] and 6.1210
U (Fall, Spring)
4-0-8 units

Techniques for the design and analysis of efficient algorithms, emphasizing methods useful in practice. Topics include sorting; search trees, heaps, and hashing; divide-and-conquer; dynamic programming; greedy algorithms; amortized analysis; graph algorithms; and shortest paths. Advanced topics may include network flow; computational geometry; number-theoretic algorithms; polynomial and matrix calculations; caching; and parallel computing.
E. Demaine, M. Goemans

6.1400[J] Computability and Complexity Theory
Same subject as 18.400[J]
Prereq: (6.1200[J] and 6.1210) or permission of instructor
U (Spring)
4-0-8 units

Mathematical introduction to the theory of computing. Rigorously explores what kinds of tasks can be efficiently solved with computers by way of finite automata, circuits, Turing machines, and communication complexity, introducing students to some major open problems in mathematics. Builds skills in classifying computational tasks in terms of their difficulty. Discusses other fundamental issues in computing, including the Halting Problem, the Church-Turing Thesis, the P versus NP problem, and the power of randomness.
R. Williams, R. Rubinfeld

6.1420 Fixed Parameter and Fine-grained Computation
Prereq: 6.1200[J], 6.1210, and (6.1220[J], 6.1400[J], or 18.404)
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: U (Fall)
3-0-9 units

An overview of the theory of parameterized algorithms and the "problem-centric" theory of fine-grained complexity, both of which reconsider how to measure the difficulty and feasibility of solving computational problems. Topics include: fixed-parameter tractability (FPT) and its characterizations, the W-hierarchy (W[1], W[2], W[P], etc.), 3-sum-hardness, all-pairs shortest paths (APSP)-equivalences, strong exponential time hypothesis (SETH) hardness of problems, and the connections to circuit complexity and other aspects of computing.
R. Williams, V. Williams

6.5210[J] Advanced Algorithms
Same subject as 18.415[J]
Prereq: 6.1220[J] and (6.1200[J], 6.3700, or 18.600)
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Fall)
5-0-7 units

First-year graduate subject in algorithms. Emphasizes fundamental algorithms and advanced methods of algorithmic design, analysis, and implementation. Surveys a variety of computational models and the algorithms for them. Data structures, network flows, linear programming, computational geometry, approximation algorithms, online algorithms, parallel algorithms, external memory, streaming algorithms.
A. Moitra, D. R. Karger

6.5220[J] Randomized Algorithms
Same subject as 18.416[J]
Prereq: (6.1200[J] or 6.3700) and (6.1220[J] or 6.5210[J])
Acad Year 2023-2024: G (Spring)
Acad Year 2024-2025: Not offered
5-0-7 units

Studies how randomization can be used to make algorithms simpler and more efficient via random sampling, random selection of witnesses, symmetry breaking, and Markov chains. Models of randomized computation. Data structures: hash tables, and skip lists. Graph algorithms: minimum spanning trees, shortest paths, and minimum cuts. Geometric algorithms: convex hulls, linear programming in fixed or arbitrary dimension. Approximate counting; parallel algorithms; online algorithms; derandomization techniques; and tools for probabilistic analysis of algorithms.
D. R. Karger

6.5230 Advanced Data Structures
Prereq: 6.1220[J]
Acad Year 2023-2024: G (Spring)
Acad Year 2024-2025: Not offered
3-0-9 units

More advanced and powerful data structures for answering several queries on the same data. Such structures are crucial in particular for designing efficient algorithms. Dictionaries; hashing; search trees. Self-adjusting data structures; linear search; splay trees; dynamic optimality. Integer data structures; word RAM. Predecessor problem; van Emde Boas priority queues; y-fast trees; fusion trees. Lower bounds; cell-probe model; round elimination. Dynamic graphs; link-cut trees; dynamic connectivity. Strings; text indexing; suffix arrays; suffix trees. Static data structures; compact arrays; rank and select. Succinct data structures; tree encodings; implicit data structures. External-memory and cache-oblivious data structures; B-trees; buffer trees; tree layout; ordered-file maintenance. Temporal data structures; persistence; retroactivity.
E. D. Demaine

6.5240 Sublinear Time Algorithms
Prereq: 6.1220[J] or permission of instructor
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Fall)
3-0-9 units

Sublinear time algorithms understand parameters and properties of input data after viewing only a minuscule fraction of it. Tools from number theory, combinatorics, linear algebra, optimization theory, distributed algorithms, statistics, and probability are covered. Topics include: testing and estimating properties of distributions, functions, graphs, strings, point sets, and various combinatorial objects.
R. Rubinfeld

6.5250[J] Distributed Algorithms
Same subject as 18.437[J]
Prereq: 6.1220[J]
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Fall)
3-0-9 units

Design and analysis of concurrent algorithms, emphasizing those suitable for use in distributed networks. Process synchronization, allocation of computational resources, distributed consensus, distributed graph algorithms, election of a leader in a network, distributed termination, deadlock detection, concurrency control, communication, and clock synchronization. Special consideration given to issues of efficiency and fault tolerance. Formal models and proof methods for distributed computation.
M. Ghaffari, N. A. Lynch

6.5310 Geometric Folding Algorithms: Linkages, Origami, Polyhedra
Prereq: 6.1220[J] or permission of instructor
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Fall)
3-0-9 units

Covers discrete geometry and algorithms underlying the reconfiguration of foldable structures, with applications to robotics, manufacturing, and biology. Linkages made from one-dimensional rods connected by hinges: constructing polynomial curves, characterizing rigidity, characterizing unfoldable versus locked, protein folding. Folding two-dimensional paper (origami): characterizing flat foldability, algorithmic origami design, one-cut magic trick. Unfolding and folding three-dimensional polyhedra: edge unfolding, vertex unfolding, gluings, Alexandrov's Theorem, hinged dissections.
E. D. Demaine

6.5320 Geometric Computing
Prereq: 6.1220[J]
Acad Year 2023-2024: G (Spring)
Acad Year 2024-2025: Not offered
3-0-9 units

Introduction to the design and analysis of algorithms for geometric problems, in low- and high-dimensional spaces. Algorithms: convex hulls, polygon triangulation, Delaunay triangulation, motion planning, pattern matching. Geometric data structures: point location, Voronoi diagrams, Binary Space Partitions. Geometric problems in higher dimensions: linear programming, closest pair problems. High-dimensional nearest neighbor search and low-distortion embeddings between metric spaces. Geometric algorithms for massive data sets: external memory and streaming algorithms. Geometric optimization.
P. Indyk

6.5340 Topics in Algorithmic Game Theory
Prereq: 6.1210 or 6.1220[J]
G (Spring)
3-0-9 units

Presents research topics at the interface of computer science and game theory, with an emphasis on algorithms and computational complexity. Explores the types of game-theoretic tools that are applicable to computer systems, the loss in system performance due to the conflicts of interest of users and administrators, and the design of systems whose performance is robust with respect to conflicts of interest inside the system. Algorithmic focus is on algorithms for equilibria, the complexity of equilibria and fixed points, algorithmic tools in mechanism design, learning in games, and the price of anarchy.
K. Daskalakis

6.5350 Matrix Multiplication and Graph Algorithms
Prereq: 6.1220[J]
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Fall)
3-0-9 units

Explores topics around matrix multiplication (MM) and its use in the design of graph algorithms. Focuses on problems such as transitive closure, shortest paths, graph matching, and other classical graph problems. Explores fast approximation algorithms when MM techniques are too expensive.
V. Williams

6.5400[J] Theory of Computation
Same subject as 18.4041[J]
Subject meets with 18.404
Prereq: 6.1200[J] or 18.200
G (Fall)
4-0-8 units

See description under subject 18.4041[J].
M. Sipser

6.5410[J] Advanced Complexity Theory
Same subject as 18.405[J]
Prereq: 18.404
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Spring)
3-0-9 units

See description under subject 18.405[J].
R. Williams

6.5420 Randomness and Computation
Prereq: 6.1220[J] and 18.4041[J]
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Spring)
3-0-9 units

The power and sources of randomness in computation. Connections and applications to computational complexity, computational learning theory, cryptography and combinatorics. Topics include: probabilistic proofs, uniform generation and approximate counting, Fourier analysis of Boolean functions, computational learning theory, expander graphs, pseudorandom generators, derandomization.
R. Rubinfeld

6.5430 Quantum Complexity Theory
Prereq: 6.1400[J], 18.4041[J], and 18.435[J]
G (Spring)
3-0-9 units

Introduction to quantum computational complexity theory, the study of the fundamental capabilities and limitations of quantum computers. Topics include complexity classes, lower bounds, communication complexity, proofs and advice, and interactive proof systems in the quantum world; classical simulation of quantum circuits. The objective is to bring students to the research frontier.
Staff

Security & Cryptography

6.1600 Foundations of Computer Security
Prereq: 6.1210 and 6.1800
U (Fall)
4-0-8 units

Fundamental notions and big ideas for achieving security in computer systems. Topics include cryptographic foundations (pseudorandomness, collision-resistant hash functions, authentication codes, signatures, authenticated encryption, public-key encryption), systems ideas (isolation, non-interference, authentication, access control, delegation, trust), and implementation techniques (privilege separation, fuzzing, symbolic execution, runtime defenses, side-channel attacks). Case studies of how these ideas are realized in deployed systems. Lab assignments apply ideas from lectures to learn how to build secure systems and how they can be attacked.
H. Corrigan-Gibbs, S. Devadas, S. Goldwasser, Y. Kalai, S. Micali, R. Rivest, V. Vaikuntanathan, N. Zeldovich

6.5610 Applied Cryptography and Security
Prereq: 6.1200[J] and 6.1800
G (Spring)
4-0-8 units

Emphasis on applied cryptography. May include: basic notion of systems security, cryptographic hash functions, symmetric cryptography (one-time pad, block ciphers, stream ciphers, message authentication codes), hash functions, key-exchange, public-key cryptography (encryption, digital signatures), elliptic curve cryptography, secret-sharing, fully homomorphic encryption, zero-knowledge proofs, and electronic voting. Assignments include a final group project. Topics may vary year to year.
H. Corrigan-Gibbs, Y. Kalai

6.5620[J] Cryptography and Cryptanalysis
Same subject as 18.425[J]
Prereq: 6.1220[J]
G (Fall)
3-0-9 units

A rigorous introduction to modern cryptography. Emphasis on the fundamental cryptographic primitives of public-key encryption, digital signatures, pseudo-random number generation, and basic protocols and their computational complexity requirements.
S. Goldwasser, S. Micali, V. Vaikuntanathan

6.5630 Advanced Topics in Cryptography
Prereq: 6.5620[J]
G (Fall)
3-0-9 units
Can be repeated for credit.

In-depth exploration of recent results in cryptography.
S. Goldwasser, S. Micali, V. Vaikuntanathan

6.5660 Computer Systems Security
Prereq: 6.1020 and 6.1800
G (Spring)
3-6-3 units

Design and implementation of secure computer systems. Lectures cover attacks that compromise security as well as techniques for achieving security, based on recent research papers. Topics include operating system security, privilege separation, capabilities, language-based security, cryptographic network protocols, trusted hardware, and security in web applications and mobile phones. Labs involve implementing and compromising a web application that sandboxes arbitrary code, and a group final project.
N. B. Zeldovich

Computer Systems

6.1800 Computer Systems Engineering
Prereq: 6.1910
U (Spring)
5-1-6 units

Topics on the engineering of computer software and hardware systems: techniques for controlling complexity; strong modularity using client-server design, operating systems; performance, networks; naming; security and privacy; fault-tolerant systems, atomicity and coordination of concurrent activities, and recovery; impact of computer systems on society. Case studies of working systems and readings from the current literature provide comparisons and contrasts. Includes a single, semester-long design project. Students engage in extensive written communication exercises. Enrollment may be limited.
K. LaCurts

6.1810 Operating System Engineering
Prereq: 6.1910
U (Fall)
3-0-9 units

Design and implementation of operating systems, and their use as a foundation for systems programming. Topics include virtual memory, file systems, threads, context switches, kernels, interrupts, system calls, interprocess communication, coordination, and interaction between software and hardware. A multi-processor operating system for RISC-V, xv6, is used to illustrate these topics. Individual laboratory assignments involve extending the xv6 operating system, for example to support sophisticated virtual memory features and networking.
A. Belay, M. F. Kaashoek, R. T. Morris

6.1820[J] Mobile and Sensor Computing
Same subject as MAS.453[J]
Prereq: 6.1800 or permission of instructor
U (Spring)
3-0-9 units

Focuses on "Internet of Things" (IoT) systems and technologies, sensing, computing, and communication. Explores fundamental design and implementation issues in the engineering of mobile and sensor computing systems. Topics include battery-free sensors, seeing through wall, robotic sensors, vital sign sensors (breathing, heartbeats, emotions), sensing in cars and autonomous vehicles, subsea IoT, sensor security, positioning technologies (including GPS and indoor WiFi), inertial sensing (accelerometers, gyroscopes, inertial measurement units, dead-reckoning), embedded and distributed system architectures, sensing with radio signals, sensing with microphones and cameras, wireless sensor networks, embedded and distributed system architectures, mobile libraries and APIs to sensors, and application case studies. Includes readings from research literature, as well as laboratory assignments and a significant term project.
H. Balakrishnan, S. Madden, F. Adib

6.1850 Computer Systems and Society
Prereq: 6.1800
U (Fall)
3-0-9 units

Explores the impact of computer systems on individual humans, society, and the environment. Examines large- and small-scale power structures that stem from low-level technical design decisions, the consequences of those structures on society, and how they can limit or provide access to certain technologies. Students learn to assess design decisions within an ethical framework and consider the impact of their decisions on non-users. Case studies of working systems and readings from the current literature provide comparisons and contrasts. Possible topics include the implications of hierarchical designs (e.g., DNS) for scale; how layered models influence what parts of a network have the power to take certain actions; and the environmental impact of proof-of-work-based systems such as Bitcoin. Enrollment may be limited.
K. LaCurts

6.5810 Operating System Engineering
Prereq: 6.1020 and 6.1800
G (Fall)
3-6-3 units

Fundamental design and implementation issues in the engineering of operating systems. Lectures based on the study of a symmetric multiprocessor version of UNIX version 6 and research papers. Topics include virtual memory; file system; threads; context switches; kernels; interrupts; system calls; interprocess communication; coordination, and interaction between software and hardware. Individual laboratory assignments accumulate in the construction of a minimal operating system (for an x86-based personal computer) that implements the basic operating system abstractions and a shell. Knowledge of programming in the C language is a prerequisite.
M. F. Kaashoek

6.5820 Computer Networks
Prereq: 6.1800 or permission of instructor
G (Fall)
4-0-8 units

Topics on the engineering and analysis of network protocols and architecture, including architectural principles for designing heterogeneous networks; transport protocols; Internet routing; router design; congestion control and network resource management; wireless networks; network security; naming; overlay and peer-to-peer networks. Readings from original research papers. Semester-long project and paper.
H. Balakrishnan, D. Katabi

6.5830 Database Systems
Subject meets with 6.5831
Prereq: (6.1800 and (6.1210 or 6.1220[J])) or permission of instructor
G (Fall)
3-0-9 units

Topics related to the engineering and design of database systems, including data models; database and schema design; schema normalization and integrity constraints; query processing; query optimization and cost estimation; transactions; recovery; concurrency control; isolation and consistency; distributed, parallel and heterogeneous databases; adaptive databases; trigger systems; pub-sub systems; semi structured data and XML querying. Lecture and readings from original research papers. Semester-long project and paper. Students taking graduate version complete different assignments. Enrollment may be limited.
S. R. Madden

6.5831 Database Systems
Subject meets with 6.5830
Prereq: (6.1800 and (6.1210 or 6.1220[J])) or permission of instructor
U (Fall)
3-0-9 units

Topics related to the engineering and design of database systems, including data models; database and schema design; schema normalization and integrity constraints; query processing; query optimization and cost estimation; transactions; recovery; concurrency control; isolation and consistency; distributed, parallel and heterogeneous databases; adaptive databases; trigger systems; pub-sub systems; semi structured data and XML querying. Lecture and readings from original research papers. Semester-long project and paper. Students taking graduate version complete different assignments. Enrollment may be limited.
S. R. Madden

6.5840 Distributed Computer Systems Engineering
Prereq: 6.1800 and permission of instructor
G (Spring)
3-0-9 units

Abstractions and implementation techniques for engineering distributed systems: remote procedure call, threads and locking, client/server, peer-to-peer, consistency, fault tolerance, and security. Readings from current literature. Individual laboratory assignments culminate in the construction of a fault-tolerant and scalable network file system. Programming experience with C/C++ required. Enrollment limited.
R. T. Morris, M. F. Kaashoek

6.5850 Principles of Computer Systems
Prereq: Permission of instructor
G (Fall)
Not offered regularly; consult department
3-0-9 units

Introduction to the basic principles of computer systems with emphasis on the use of rigorous techniques as an aid to understanding and building modern computing systems. Particular attention paid to concurrent and distributed systems. Topics include: specification and verification, concurrent algorithms, synchronization, naming, Networking, replication techniques (including distributed cache management), and principles and algorithms for achieving reliability.
M. F. Kaashoek, B. Lampson, N. B. Zeldovich

Computer Architecture

6.1903 Introduction to Low-level Programming in C and Assembly (6.1900)
Prereq: 6.100A
U (Spring; first half of term)
2-2-2 units
Credit cannot also be received for 6.1904

Introduction to C and assembly language for students coming from a Python background (6.100A). Studies the C language, focusing on memory and associated topics including pointers, and how different data structures are stored in memory, the stack, and the heap in order to build a strong understanding of the constraints involved in manipulating complex data structures in modern computational systems. Studies assembly language to facilitate a firm understanding of how high-level languages are translated to machine-level instructions.
J. D. Steinmeyer, S. Hanono Wachman

6.1904 Introduction to Low-level Programming in C and Assembly (New)
Prereq: 6.100A
U (Spring; second half of term)
2-2-2 units
Credit cannot also be received for 6.1903

Introduction to C and assembly language for students coming from a Python background (6.100A). Studies the C language, focusing on memory and associated topics including pointers, and how different data structures are stored in memory, the stack, and the heap in order to build a strong understanding of the constraints involved in manipulating complex data structures in modern computational systems. Studies assembly language to facilitate a firm understanding of how high-level languages are translated to machine-level instructions.
J. D. Steinmeyer, S. Hanono Wachman

6.1910 Computation Structures
Prereq: Physics II (GIR), 6.100A, and (6.1900 or 6.9010)
U (Fall, Spring)
4-0-8 units. REST

Provides an introduction to the design of digital systems and computer architecture. Emphasizes expressing all hardware designs in a high-level hardware language and synthesizing the designs. Topics include combinational and sequential circuits, instruction set abstraction for programmable hardware, single-cycle and pipelined processor implementations, multi-level memory hierarchies, virtual memory, exceptions and I/O, and parallel systems.
S. Z. Hanono Wachman, D. Sanchez

6.1920 Constructive Computer Architecture
Prereq: 6.1910
U (Spring)
3-8-1 units

Illustrates a constructive (as opposed to a descriptive) approach to computer architecture. Topics include combinational and pipelined arithmetic-logic units (ALU), in-order pipelined microarchitectures, branch prediction, blocking and unblocking caches, interrupts, virtual memory support, cache coherence and multicore architectures. Labs in a modern Hardware Design Language (HDL) illustrate various aspects of microprocessor design, culminating in a term project in which students present a multicore design running on an FPGA board.
Arvind

6.5900 Computer System Architecture
Prereq: 6.1910
G (Fall)
4-0-8 units

Introduction to the principles underlying modern computer architecture. Emphasizes the relationship among technology, hardware organization, and programming systems in the evolution of computer architecture. Topics include pipelined, out-of-order, and speculative execution; caches, virtual memory and exception handling, superscalar, very long instruction word (VLIW), vector, and multithreaded processors; on-chip networks, memory models, synchronization, and cache coherence protocols for multiprocessors.
J. S. Emer, D. Sanchez

6.5910 Complex Digital Systems Design
Prereq: 6.1910
G (Spring)
Not offered regularly; consult department
5-5-2 units

Introduction to the design and implementation of large-scale digital systems using hardware description languages and high-level synthesis tools in conjunction with standard commercial electronic design automation (EDA) tools. Emphasizes modular and robust designs, reusable modules, correctness by construction, architectural exploration, meeting area and timing constraints, and developing functional field-programmable gate array (FPGA) prototypes. Extensive use of CAD tools in weekly labs serve as preparation for a multi-person design project on multi-million gate FPGAs. Enrollment may be limited.
Arvind

6.5920 Parallel Computing
Prereq: 6.1910 or permission of instructor
G (Spring)
Not offered regularly; consult department
3-0-9 units

Introduction to parallel and multicore computer architecture and programming. Topics include the design and implementation of multicore processors; networking, video, continuum, particle and graph applications for multicores; communication and synchronization algorithms and mechanisms; locality in parallel computations; computational models, including shared memory, streams, message passing, and data parallel; multicore mechanisms for synchronization, cache coherence, and multithreading. Performance evaluation of multicores; compilation and runtime systems for parallel computing. Substantial project required.
A. Agarwal

6.5930 Hardware Architecture for Deep Learning
Subject meets with 6.5931
Prereq: 6.1910 and (6.3000 or 6.3900)
G (Spring)
3-3-6 units

Introduction to the design and implementation of hardware architectures for efficient processing of deep learning algorithms and tensor algebra in AI systems. Topics include basics of deep learning, optimization principles for programmable platforms, design principles of accelerator architectures, co-optimization of algorithms and hardware (including sparsity) and use of advanced technologies (including memristors and optical computing). Includes labs involving modeling and analysis of hardware architectures, architecting deep learning inference systems, and an open-ended design project. Students taking graduate version complete additional assignments.
V. Sze, J. Emer

6.5931 Hardware Architecture for Deep Learning
Subject meets with 6.5930
Prereq: 6.1910 and (6.3000 or 6.3900)
U (Spring)
3-3-6 units

Introduction to the design and implementation of hardware architectures for efficient processing of deep learning algorithms and tensor algebra in AI systems. Topics include basics of deep learning, optimization principles for programmable platforms, design principles of accelerator architectures, co-optimization of algorithms and hardware (including sparsity) and use of advanced technologies (including memristors and optical computing). Includes labs involving modeling and analysis of hardware architectures, architecting deep learning inference systems, and an open-ended design project. Students taking graduate version complete additional assignments.
V. Sze, J. Emer

6.5940 TinyML and Efficient Deep Learning Computing (New)
Prereq: 6.1910 and 6.3900
G (Fall)
3-0-9 units

Introduces efficient deep learning computing techniques that enable powerful deep learning applications on resource-constrained devices. Topics include model compression, pruning, quantization, neural architecture search, distributed training, data/model parallellism, gradient compression, on-device fine-tuning. It also introduces application-specific acceleration techniques for video recognition, point cloud, and generative AI (diffusion model, LLM). Students will get hands-on experience accelerating deep learning applications with an open-ended design project.
S. Han

6.5950 Secure Hardware Design (New)
Subject meets with 6.5951
Prereq: 6.1910
G (Spring)
3-0-9 units

Introduction to basic concepts, principles, and implementation issues in the designing of secure hardware systems. Through a mixture of lectures and paper discussions, covers state-of-the-art security attacks and defenses targeting the computer architecture, digital circuits, and physics layers of computer systems. Emphasizes both the conceptual and the practical aspects of security issues in modern hardware systems. Topics include microarchitectural timing side channels, speculative execution attacks, RowHammer, Trusted Execution Environment, physical attacks, hardware support for software security, and verification of digital systems. Students taking graduate version complete additional assignments.
M. Yan

6.5951 Secure Hardware Design (New)
Subject meets with 6.5950
Prereq: 6.1910
U (Spring)
3-0-9 units

Introduction to basic concepts, principles, and implementation issues in the designing of secure hardware systems. Through a mixture of lectures and paper discussions, covers state-of-the-art security attacks and defenses targeting the computer architecture, digital circuits, and physics layers of computer systems. Emphasizes both the conceptual and the practical aspects of security issues in modern hardware systems. Topics include microarchitectural timing side channels, speculative execution attacks, RowHammer, Trusted Execution Environment, physical attacks, hardware support for software security, and verification of digital systems. Students taking graduate version complete additional assignments.
M. Yan

Circuits & Applications

6.2000 Electrical Circuits: Modeling and Design of Physical Systems
Prereq: Physics II (GIR)
U (Fall, Spring)
3-2-7 units. REST

Fundamentals of linear systems, and abstraction modeling of multi-physics lumped and distributed systems using lumped electrical circuits. Linear networks involving independent and dependent sources, resistors, capacitors, and inductors. Extensions to include operational amplifiers and transducers. Dynamics of first- and second-order networks; analysis and design in the time and frequency domains; signal and energy processing applications. Design exercises. Weekly laboratory with microcontroller and transducers.
J. H. Lang, T. Palacios, D. J. Perreault, J. Voldman

6.2020[J] Electronics Project Laboratory
Same subject as EC.120[J]
Prereq: None
U (Fall, Spring)
1-2-3 units

Intuition-based introduction to electronics, electronic components, and test equipment such as oscilloscopes, multimeters, and signal generators. Key components studied and used are op-amps, comparators, bi-polar transistors, and diodes (including LEDs). Students design, build, and debug small electronics projects (often featuring sound and light) to put their new knowledge into practice. Upon completing the class, students can take home a kit of components. Intended for students with little or no previous background in electronics. Enrollment may be limited.
J. Bales

6.2030 Electronics First Laboratory
Prereq: None. *Coreq: Physics II (GIR)*
U (Spring)
4-4-4 units

Practical introduction to the design and construction of electronic circuits for information processing and control. Laboratory exercises include activities such as the construction of oscillators for a simple musical instrument, a laser audio communicator, a countdown timer, an audio amplifier, and a feedback-controlled solid-state lighting system for daylight energy conservation. Introduces basic electrical components including resistors, capacitors, and inductors; basic assembly techniques for electronics include breadboarding and soldering; and programmable system-on-chip electronics and C programming language. Enrollment limited.
S. B. Leeb

6.2040 Analog Electronics Laboratory
Prereq: 6.2000
U (Spring)
2-9-1 units. Institute LAB

Experimental laboratory explores the design, construction, and debugging of analog electronic circuits. Lectures and laboratory projects in the first half of the course investigate the performance characteristics of semiconductor devices (diodes, BJTs, and MOSFETs) and functional analog building blocks, including single-stage amplifiers, op amps, small audio amplifier, filters, converters, sensor circuits, and medical electronics (ECG, pulse-oximetry). Projects involve design, implementation, and presentation in an environment similar to that of industry engineering design teams. Instruction and practice in written and oral communication provided. Opportunity to simulate real-world problems and solutions that involve tradeoffs and the use of engineering judgment.
G. Hom, N. Reiskarimian

6.2050 Digital Systems Laboratory
Prereq: 6.1910 or permission of instructor
U (Fall)
3-7-2 units. Institute LAB

Lab-intensive subject that investigates digital systems with a focus on FPGAs. Lectures and labs cover logic, flip flops, counters, timing, synchronization, finite-state machines, digital signal processing, communication protocols, and modern sensors. Prepares students for the design and implementation of a large-scale final project of their choice: games, music, digital filters, wireless communications, video, or graphics. Extensive use of System/Verilog for describing and implementing and verifying digital logic designs.
J. Steinmeyer, G. P. Hom, A. P. Chandrakasan

6.2060 Microcomputer Project Laboratory
Subject meets with 6.2061
Prereq: 6.1910, 6.2000, or 6.3000
U (Spring)
3-6-3 units. Institute LAB

Introduces analysis and design of embedded systems. Microcontrollers provide adaptation, flexibility, and real-time control. Emphasizes construction of complete systems, including a five-axis robot arm, a fluorescent lamp ballast, a tomographic imaging station (e.g., a CAT scan), and a simple calculator. Presents a wide range of basic tools, including software and development tools, programmable system on chip, peripheral components such as A/D converters, communication schemes, signal processing techniques, closed-loop digital feedback control, interface and power electronics, and modeling of electromechanical systems. Includes a sequence of assigned projects, followed by a final project of the student's choice, emphasizing creativity and uniqueness. Provides instruction in written and oral communication. To satisfy the independent inquiry component of this subject, students expand the scope of their laboratory project.
S. B. Leeb

6.2061 Microcomputer Project Laboratory - Independent Inquiry
Subject meets with 6.2060
Prereq: 6.1910, 6.2000, or 6.3000
U (Spring)
3-9-3 units

Introduces analysis and design of embedded systems. Microcontrollers provide adaptation, flexibility, and real-time control. Emphasizes construction of complete systems, including a five-axis robot arm, a fluorescent lamp ballast, a tomographic imaging station (e.g., a CAT scan), and a simple calculator. Presents a wide range of basic tools, including software and development tools, programmable system on chip, peripheral components such as A/D converters, communication schemes, signal processing techniques, closed-loop digital feedback control, interface and power electronics, and modeling of electromechanical systems. Includes a sequence of assigned projects, followed by a final project of the student's choice, emphasizing creativity and uniqueness. Provides instruction in written and oral communication. Students taking independent inquiry version 6.2061 expand the scope of their laboratory project.
S. B. Leeb

6.2080 Semiconductor Electronic Circuits
Prereq: 6.2000
U (Spring)
3-2-7 units

Provides an introduction to basic circuit design, starting from basic semiconductor devices such as diodes and transistors, large and small signal models and analysis, to circuits such as basic amplifier and opamp circuits. Labs give students access to CAD/EDA tools to design, analyze, and layout analog circuits. At the end of the term, students have their chip design fabricated using a 22nm FinFET CMOS process.
R. Han, N. Reiskarimian

6.2090 Solid-State Circuits
Subject meets with 6.2092
Prereq: 6.2040, 6.2080, or permission of instructor
U (Fall)
3-2-7 units

Fosters deep understanding and intuition that is crucial in innovating analog circuits and optimizing the whole system in bipolar junction transistor (BJT) and metal oxide semiconductor (MOS) technologies. Covers both theory and real-world applications of basic amplifier structures, operational amplifiers, temperature sensors, bandgap references. Covers topics such as noise, linearity and stability. Homework and labs give students access to CAD/EDA tools to design and analyze analog circuits. Provides practical experience through lab exercises, including a broadband amplifier design and characterization. Students taking graduate version complete additional assignments.
N. Reiskarimian, H.-S. Lee, R. Han

6.2092 Solid-State Circuits
Subject meets with 6.2090
Prereq: 6.2040, 6.2080, or permission of instructor
G (Fall)
3-2-7 units

Fosters deep understanding and intuition that is crucial in innovating analog circuits and optimizing the whole system in bipolar junction transistor (BJT) and metal oxide semiconductor (MOS) technologies. Covers both theory and real-world applications of basic amplifier structures, operational amplifiers, temperature sensors, bandgap references. Covers topics such as noise, linearity and stability. Homework and labs give students access to CAD/EDA tools to design and analyze analog circuits. Provides practical experience through lab exercises, including a broadband amplifier design and characterization. Students taking graduate version complete additional assignments.
N. Reiskarimian, H.-S. Lee, R. Han

6.6000 CMOS Analog and Mixed-Signal Circuit Design
Prereq: 6.2090
G (Spring)
3-0-9 units

A detailed exposition of the principles involved in designing and optimizing analog and mixed-signal circuits in CMOS technologies. Small-signal and large-signal models. Systemic methodology for device sizing and biasing. Basic circuit building blocks. Operational amplifier design. Large signal considerations. Principles of switched capacitor networks including switched-capacitor and continuous-time integrated filters. Basic and advanced A/D and D/A converters, delta-sigma modulators, RF and other signal processing circuits. Design projects on op amps and subsystems are a required part of the subject.
H. S. Lee, R. Han

6.6010 Analysis and Design of Digital Integrated Circuits
Prereq: 6.1910 and (6.2080 or 6.2500)
G (Fall)
3-3-6 units

Device and circuit level optimization of digital building blocks. Circuit design styles for logic, arithmetic, and sequential blocks. Estimation and minimization of energy consumption. Interconnect models and parasitics, device sizing and logical effort, timing issues (clock skew and jitter), and active clock distribution techniques. Memory architectures, circuits (sense amplifiers), and devices. Evaluation of how design choices affect tradeoffs across key metrics including energy consumption, speed, robustness, and cost. Extensive use of modern design flow and EDA/CAD tools for the analysis and design of digital building blocks and digital VLSI design for labs and design projects
V. Sze, A. P. Chandrakasan

6.6020 High Speed Communication Circuits
Prereq: 6.2090
G (Fall)
3-3-6 units

Principles and techniques of high-speed integrated circuits used in wireless/wireline data links and remote sensing. On-chip passive component design of inductors, capacitors, and antennas. Analysis of distributed effects, such as transmission line modeling, S-parameters, and Smith chart. Transceiver architectures and circuit blocks, which include low-noise amplifiers, mixers, voltage-controlled oscillators, power amplifiers, and frequency dividers. Involves IC/EM simulation and laboratory projects.
R. Han

Energy

6.2200 Electric Energy Systems
Prereq: 6.2000
U (Fall)
4-0-8 units

Analysis and design of modern energy conversion and delivery systems. Develops a solid foundation in electromagnetic phenomena with a focus on electrical energy distribution, electro-mechanical energy conversion (motors and generators), and electrical-to-electrical energy conversion (DC-DC, DC-AC power conversion). Students apply the material covered to consider critical challenges associated with global energy systems, with particular examples related to the electrification of transport and decarbonization of the grid.
R. Ram, J. H. Lang, M. Ilic, D. J. Perreault

6.2210 Electromagnetic Fields, Forces and Motion
Subject meets with 6.6210
Prereq: Physics II (GIR) and 18.03
U (Fall)
4-0-8 units

Study of electromagnetics and electromagnetic energy conversion leading to an understanding of devices, including electromagnetic sensors, actuators, motors and generators. Quasistatic Maxwell's equations and the Lorentz force law. Studies of the quasistatic fields and their sources through solutions of Poisson's and Laplace's equations. Boundary conditions and multi-region boundary-value problems. Steady-state conduction, polarization, and magnetization. Charge conservation and relaxation, and magnetic induction and diffusion. Extension to moving materials. Electric and magnetic forces and force densities derived from energy, and stress tensors. Extensive use of engineering examples. Students taking graduate version complete additional assignments.
J. H. Lang

6.2220 Power Electronics Laboratory
Subject meets with 6.2221, 6.2222
Prereq: 6.2000 or 6.3100
U (Fall)
3-6-3 units. Institute LAB

Introduces the design and construction of power electronic circuits and motor drives. Laboratory exercises include the construction of drive circuitry for an electric go-cart, flash strobes, computer power supplies, three-phase inverters for AC motors, and resonant drives for lamp ballasts and induction heating. Basic electric machines introduced include DC, induction, and permanent magnet motors, with drive considerations. Provides instruction in written and oral communication. Students taking independent inquiry version 6.2221 expand the scope of their laboratory project.
S. B. Leeb

6.2221 Power Electronics Laboratory - Independent Inquiry
Subject meets with 6.2220, 6.2222
Prereq: 6.2000 or 6.3000
U (Fall)
3-9-3 units

Introduces the design and construction of power electronic circuits and motor drives. Laboratory exercises include the construction of drive circuitry for an electric go-cart, flash strobes, computer power supplies, three-phase inverters for AC motors, and resonant drives for lamp ballasts and induction heating. Basic electric machines introduced include DC, induction, and permanent magnet motors, with drive considerations. Provides instruction in written and oral communication. To satisfy the independent inquiry component of this subject, students expand the scope of their laboratory project.
S. B. Leeb

6.2222 Power Electronics Laboratory
Subject meets with 6.2220, 6.2221
Prereq: Permission of instructor
G (Fall)
3-9-3 units

Hands-on introduction to the design and construction of power electronic circuits and motor drives. Laboratory exercises (shared with 6.131 and 6.1311) include the construction of drive circuitry for an electric go-cart, flash strobes, computer power supplies, three-phase inverters for AC motors, and resonant drives for lamp ballasts and induction heating. Basic electric machines introduced including DC, induction, and permanent magnet motors, with drive considerations. Students taking graduate version complete additional assignments and an extended final project.
S. B. Leeb

6.6210 Electromagnetic Fields, Forces and Motion
Subject meets with 6.2210
Prereq: Physics II (GIR) and 18.03
G (Fall)
4-0-8 units

Study of electromagnetics and electromagnetic energy conversion leading to an understanding of devices, including electromagnetic sensors, actuators, motors and generators. Quasistatic Maxwell's equations and the Lorentz force law. Studies of the quasistatic fields and their sources through solutions of Poisson's and Laplace's equations. Boundary conditions and multi-region boundary-value problems. Steady-state conduction, polarization, and magnetization. Charge conservation and relaxation, and magnetic induction and diffusion. Extension to moving materials. Electric and magnetic forces and force densities derived from energy, and stress tensors. Extensive use of engineering examples. Students taking graduate version complete additional assignments.
J. H. Lang

6.6220 Power Electronics
Prereq: 6.2500
G (Spring)
3-0-9 units

The application of electronics to energy conversion and control. Modeling, analysis, and control techniques. Design of power circuits including inverters, rectifiers, and dc-dc converters. Analysis and design of magnetic components and filters. Characteristics of power semiconductor devices. Numerous application examples, such as motion control systems, power supplies, and radio-frequency power amplifiers.
D. J. Perreault

6.6280 Electric Machines
Prereq: 6.2200, 6.690, or permission of instructor
G (Fall)
Not offered regularly; consult department
3-0-9 units

Treatment of electromechanical transducers, rotating and linear electric machines. Lumped-parameter electromechanics. Power flow using Poynting's theorem, force estimation using the Maxwell stress tensor and Principle of virtual work. Development of analytical techniques for predicting device characteristics: energy conversion density, efficiency; and of system interaction characteristics: regulation, stability, controllability, and response. Use of electric machines in drive systems. Problems taken from current research.
J. L. Kirtley, Jr.

Electromagnetics, Photonics, and Quantum

6.2300 Electromagnetics Waves and Applications
Prereq: Calculus II (GIR) and Physics II (GIR)
U (Spring)
3-5-4 units

Analysis and design of modern applications that employ electromagnetic phenomena for signals and power transmission in RF, microwaves, optical and wireless communication systems. Fundamentals include dynamic solutions for Maxwell's equations; electromagnetic power and energy, waves in media, metallic and dielectric waveguides, radiation, and diffraction; resonance; filters; and acoustic analogs. Lab activities range from building to testing of devices and systems (e.g., antenna arrays, radars, dielectric waveguides). Students work in teams on self-proposed maker-style design projects with a focus on fostering creativity, teamwork, and debugging skills. 6.2000 and 6.3000 are recommended but not required.
K. O'Brien, L. Daniel

6.2370 Modern Optics Project Laboratory
Subject meets with 6.6370
Prereq: 6.3000
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: U (Fall)
3-5-4 units. Institute LAB

Lectures, laboratory exercises and projects on optical signal generation, transmission, detection, storage, processing and display. Topics include polarization properties of light; reflection and refraction; coherence and interference; Fraunhofer and Fresnel diffraction; holography; Fourier optics; coherent and incoherent imaging and signal processing systems; optical properties of materials; lasers and LEDs; electro-optic and acousto-optic light modulators; photorefractive and liquid-crystal light modulation; display technologies; optical waveguides and fiber-optic communication systems; photodetectors. Students may use this subject to find an advanced undergraduate project. Students engage in extensive oral and written communication exercises. Recommended prerequisite: 8.03.
C. Warde

6.2400 Introduction to Quantum Systems Engineering
Prereq: 6.2300 and (18.06 or 18.C06[J])
U (Fall)
4-2-6 units

Introduction to the quantum mechanics needed to engineer quantum systems for computation, communication, and sensing. Topics include: motivation for quantum engineering, qubits and quantum gates, rules of quantum mechanics, mathematical background, quantum electrical circuits and other physical quantum systems, harmonic and anharmonic oscillators, measurement, the Schrödinger equation, noise, entanglement, benchmarking, quantum communication, and quantum algorithms. No prior experience with quantum mechanics is assumed.
K. Berggren, A. Natarajan, K. O'Brien

6.2410 Quantum Engineering Platforms
Prereq: 6.2400, 6.6400, 18.435[J], or (8.04 and 8.05)
U (Spring)
1-5-6 units

Provides practical knowledge and quantum engineering experience with several physical platforms for quantum computation, communication, and sensing, including photonics, superconducting qubits, and trapped ions. Labs include both a hardware component — to gain experience with challenges, design, and non-idealities — and a cloud component to run algorithms on state of the art commercial systems. Use entangled photons to communicate securely (quantum key distribution). Run quantum algorithms on trapped ion and superconducting quantum computers.
D. Englund

6.6300 Electromagnetics
Prereq: Physics II (GIR) and 6.3000
G (Fall)
4-0-8 units

Explores electromagnetic phenomena in modern applications, including wireless and optical communications, circuits, computer interconnects and peripherals, microwave communications and radar, antennas, sensors, micro-electromechanical systems, and power generation and transmission. Fundamentals include quasistatic and dynamic solutions to Maxwell's equations; waves, radiation, and diffraction; coupling to media and structures; guided and unguided waves; modal expansions; resonance; acoustic analogs; and forces, power, and energy.
Q. Hu, J. Notaros

6.6310 Optics and Photonics
Prereq: 6.2300 or 8.03
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Fall)
3-0-9 units

Introduction to fundamental concepts and techniques of optics, photonics, and fiber optics, aimed at developing skills for independent research. Topics include: Review of Maxwell's equations, light propagation, reflection and transmission, dielectric mirrors and filters. Scattering matrices, interferometers, and interferometric measurement. Fresnel and Fraunhoffer diffraction theory. Lenses, optical imaging systems, and software design tools. Gaussian beams, propagation and resonator design. Optical waveguides, optical fibers and photonic devices for encoding and detection. Discussion of research operations / funding and professional development topics. The course reviews and introduces mathematical methods and techniques, which are fundamental in optics and photonics, but also useful in many other engineering specialties.
J. G. Fujimoto

6.6330 Fundamentals of Photonics
Subject meets with 6.6331
Prereq: 2.71, 6.2300, or 8.07
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Fall)
3-0-9 units

Covers the fundamentals of optics and the interaction of light and matter, leading to devices such as light emitting diodes, optical amplifiers, and lasers. Topics include classical ray, wave, beam, and Fourier optics; Maxwell's electromagnetic waves; resonators; quantum theory of photons; light-matter interaction; laser amplification; lasers; and semiconductors optoelectronics. Students taking graduate version complete additional assignments.
D. R. Englund

6.6331 Fundamentals of Photonics
Subject meets with 6.6330
Prereq: 2.71, 6.2300, or 8.07
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: U (Fall)
3-0-9 units

Covers the fundamentals of optics and the interaction of light and matter, leading to devices such as light emitting diodes, optical amplifiers, and lasers. Topics include classical ray, wave, beam, and Fourier optics; Maxwell's electromagnetic waves; resonators; quantum theory of photons; light-matter interaction; laser amplification; lasers; and semiconductors optoelectronics. Students taking graduate version complete additional assignments.
D. R. Englund

6.6340[J] Nonlinear Optics
Same subject as 8.431[J]
Prereq: 6.2300 or 8.03
G (Spring)
3-0-9 units

Techniques of nonlinear optics with emphasis on fundamentals for research in optics, photonics, spectroscopy, and ultrafast science. Topics include: electro-optic modulators and devices, sum and difference frequency generation, and parametric conversion. Nonlinear propagation effects in optical fibers including self-phase modulation, pulse compression, solitons, communication, and femtosecond fiber lasers. Review of quantum mechanics, interaction of light with matter, laser gain and operation, density matrix techniques, perturbation theory, diagrammatic methods, nonlinear spectroscopies, ultrafast lasers and measurements. Discussion of research operations and funding and professional development topics. Introduces fundamental methods and techniques needed for independent research in advanced optics and photonics, but useful in many other engineering and physics disciplines.
J. G. Fujimoto

6.6370 Optical Imaging Devices, and Systems
Subject meets with 6.2370
Prereq: 6.3000
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Fall)
3-0-9 units

Principles of operation and applications of optical imaging devices and systems (includes optical signal generation, transmission, detection, storage, processing and display). Topics include review of the basic properties of electromagnetic waves; coherence and interference; diffraction and holography; Fourier optics; coherent and incoherent imaging and signal processing systems; optical properties of materials; lasers and LEDs; electro-optic and acousto-optic light modulators; photorefractive and liquid-crystal light modulation; spatial light modulators and displays; near-eye and projection displays, holographic and other 3-D display schemes, photodetectors; 2-D and 3-D optical storage technologies; adaptive optical systems; role of optics in next-generation computers. Requires a research paper on a specific contemporary optical imaging topic. Recommended prerequisite: 8.03.
C. Warde

6.6400 Applied Quantum and Statistical Physics
Prereq: 18.06
G (Fall)
4-0-8 units

Elementary quantum mechanics and statistical physics. Introduces applied quantum physics. Emphasizes experimental basis for quantum mechanics. Applies Schrodinger's equation to the free particle, tunneling, the harmonic oscillator, and hydrogen atom. Variational methods. Elementary statistical physics; Fermi-Dirac, Bose-Einstein, and Boltzmann distribution functions. Simple models for metals, semiconductors, and devices such as electron microscopes, scanning tunneling microscope, thermonic emitters, atomic force microscope, and more. Some familiarity with continuous time Fourier transforms recommended.
P. L. Hagelstein

6.6410[J] Quantum Computation
Same subject as 2.111[J], 8.370[J], 18.435[J]
Prereq: 8.05, 18.06, 18.700, 18.701, or 18.C06[J]
G (Fall)
3-0-9 units

See description under subject 18.435[J].
I. Chuang, A. Harrow, P. Shor

6.6420[J] Quantum Information Science
Same subject as 8.371[J], 18.436[J]
Prereq: 18.435[J]
G (Spring)
3-0-9 units

See description under subject 8.371[J].
I. Chuang, A. Harrow

Nanoelectronics & Nanotechnology

6.2500 Nanoelectronics and Computing Systems
Prereq: 6.2000
U (Spring)
4-0-8 units

Studies interaction between materials, semiconductor physics, electronic devices, and computing systems. Develops intuition of how transistors operate. Topics range from introductory semiconductor physics to modern state-of-the-art nano-scale devices. Considers how innovations in devices have driven historical progress in computing, and explores ideas for further improvements in devices and computing. Students apply material to understand how building improved computing systems requires knowledge of devices, and how making the correct device requires knowledge of computing systems. Includes a design project for practical application of concepts, and labs for experience building silicon transistors and devices.
A. I. Akinwande, J. Kong, T. Palacios, M. Shulaker

6.2530 Introduction to Nanoelectronics
Subject meets with 6.2532
Prereq: 6.3000
U (Fall)
Not offered regularly; consult department
4-0-8 units

Transistors at the nanoscale. Quantization, wavefunctions, and Schrodinger's equation. Introduction to electronic properties of molecules, carbon nanotubes, and crystals. Energy band formation and the origin of metals, insulators and semiconductors. Ballistic transport, Ohm's law, ballistic versus traditional MOSFETs, fundamental limits to computation.
M. A. Baldo

6.2532 Nanoelectronics
Subject meets with 6.2530
Prereq: 6.3000
G (Fall)
Not offered regularly; consult department
4-0-8 units

Meets with undergraduate subject 6.2530, but requires the completion of additional/different homework assignments and or projects. See subject description under 6.2530.
M. A. Baldo

6.2540 Nanotechnology: From Atoms to Systems
Prereq: Physics II (GIR)
U (Fall)
2-3-7 units

Introduces the fundamentals of applied quantum mechanics, materials science, and fabrication skills needed to design, engineer, and build emerging nanodevices with diverse applications in energy, memory, display, communications, and sensing. Focuses on the application and outlines the full progression from the fundamentals to the implemented device and functional technology. Closely integrates lectures with design-oriented laboratory modules.
F. Niroui, R. Ram, L. Liu, T. Palacios

6.2600[J] Micro/Nano Processing Technology
Same subject as 3.155[J]
Prereq: Calculus II (GIR), Chemistry (GIR), Physics II (GIR), or permission of instructor
U (Spring)
3-4-5 units

Introduces the theory and technology of micro/nano fabrication. Includes lectures and laboratory sessions on processing techniques: wet and dry etching, chemical and physical deposition, lithography, thermal processes, packaging, and device and materials characterization. Homework uses process simulation tools to build intuition about higher order effects. Emphasizes interrelationships between material properties and processing, device structure, and the electrical, mechanical, optical, chemical or biological behavior of devices. Students fabricate solar cells, and a choice of MEMS cantilevers or microfluidic mixers. Students formulate their own device idea, either based on cantilevers or mixers, then implement and test their designs in the lab. Students engage in extensive written and oral communication exercises. Course provides background for research work related to micro/nano fabrication. Enrollment limited.
J. del Alamo, J. Michel, J. Scholvin

6.6500[J] Integrated Microelectronic Devices
Same subject as 3.43[J]
Prereq: 3.42 or 6.2500
G (Fall)
4-0-8 units

Covers physics of microelectronic semiconductor devices for integrated circuit applications. Topics include semiconductor fundamentals, p-n junction, metal-oxide semiconductor structure, metal-semiconductor junction, MOS field-effect transistor, and bipolar junction transistor. Emphasizes physical understanding of device operation through energy band diagrams and short-channel MOSFET device design and modern device scaling. Familiarity with MATLAB recommended.
J. A. del Alamo, H. L. Tuller

6.6510 Physics for Solid-State Applications
Prereq: 6.2300 and 6.6400
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Spring)
5-0-7 units

Classical and quantum models of electrons and lattice vibrations in solids, emphasizing physical models for elastic properties, electronic transport, and heat capacity. Crystal lattices, electronic energy band structures, phonon dispersion relations, effective mass theorem, semiclassical equations of motion, electron scattering and semiconductor optical properties. Band structure and transport properties of selected semiconductors. Connection of quantum theory of solids with quasi-Fermi levels and Boltzmann transport used in device modeling.
Q. Hu, R. Ram

6.6520 Semiconductor Optoelectronics: Theory and Design
Prereq: 6.2500 and 6.6400
Acad Year 2023-2024: G (Spring)
Acad Year 2024-2025: Not offered
3-0-9 units

Focuses on the physics of the interaction of photons with semiconductor materials. Uses the band theory of solids to calculate the absorption and gain of semiconductor media; and uses rate equation formalism to develop the concepts of laser threshold, population inversion, and modulation response. Presents theory and design for photodetectors, solar cells, modulators, amplifiers, and lasers. Introduces noise models for semiconductor devices, and applications of optoelectronic devices to fiber optic communications.
R. J. Ram

6.6530 Physics of Solids
Prereq: 6.6510 or 8.231
G (Fall)
Not offered regularly; consult department
4-0-8 units

Continuation of 6.730 emphasizing applications-related physical issues in solids. Topics include: electronic structure and energy band diagrams of semiconductors, metals, and insulators; Fermi surfaces; dynamics of electrons under electric and magnetic fields; classical diffusive transport phenomena such as electrical and thermal conduction and thermoelectric phenomena; quantum transport in tunneling and ballistic devices; optical properties of metals, semiconductors, and insulators; impurities and excitons; photon-lattice interactions; Kramers-Kronig relations; optoelectronic devices based on interband and intersubband transitions; magnetic properties of solids; exchange energy and magnetic ordering; magneto-oscillatory phenomena; quantum Hall effect; superconducting phenomena and simple models.
Q. Hu

6.6600[J] Nanostructure Fabrication
Same subject as 2.391[J]
Prereq: 2.710, 6.2370, 6.2600[J], or permission of instructor
G (Spring)
4-0-8 units

Describes current techniques used to analyze and fabricate nanometer-length-scale structures and devices. Emphasizes imaging and patterning of nanostructures, including fundamentals of optical, electron (scanning, transmission, and tunneling), and atomic-force microscopy; optical, electron, ion, and nanoimprint lithography, templated self-assembly, and resist technology. Surveys substrate characterization and preparation, facilities, and metrology requirements for nanolithography. Addresses nanodevice processing methods, such as liquid and plasma etching, lift-off, electroplating, and ion-implant. Discusses applications in nanoelectronics, nanomaterials, and nanophotonics.
K. K. Berggren

6.6630[J] Control of Manufacturing Processes
Same subject as 2.830[J]
Prereq: 2.008, 6.2600[J], or 6.3700
G (Fall)
3-0-9 units

See description under subject 2.830[J].
D. E. Hardt, D. S. Boning

Signal Processing

6.3000 Signal Processing
Prereq: 6.100A and 18.03
U (Fall, Spring)
6-0-6 units. REST

Fundamentals of signal processing, focusing on the use of Fourier methods to analyze and process signals such as sounds and images. Topics include Fourier series, Fourier transforms, the Discrete Fourier Transform, sampling, convolution, deconvolution, filtering, noise reduction, and compression. Applications draw broadly from areas of contemporary interest with emphasis on both analysis and design.
D. M. Freeman, A. Hartz

6.3010 Signals, Systems and Inference
Prereq: 6.3000 and (6.3700, 6.3800, or 18.05)
U (Spring)
4-0-8 units

Covers signals, systems and inference in communication, control and signal processing. Topics include input-output and state-space models of linear systems driven by deterministic and random signals; time- and transform-domain representations in discrete and continuous time; and group delay. State feedback and observers. Probabilistic models; stochastic processes, correlation functions, power spectra, spectral factorization. Least-mean square error estimation; Wiener filtering. Hypothesis testing; detection; matched filters.
P. L. Hagelstein, G. C. Verghese

6.3020[J] Fundamentals of Music Processing (New number 6.187)
Same subject as 21M.387[J]
Subject meets with 21M.587
Prereq: 6.3000 and 21M.051
U (Fall)
3-0-9 units. HASS-A

See description under subject 21M.387[J].
E. Egozy

6.7000 Discrete-Time Signal Processing
Prereq: 6.3010
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Fall)
4-0-8 units

Representation, analysis, and design of discrete time signals and systems. Decimation, interpolation, and sampling rate conversion. Noise shaping. Flowgraph structures for DT systems. IIR and FIR filter design techniques. Parametric signal modeling, linear prediction, and lattice filters. Discrete Fourier transform, DFT computation, and FFT algorithms. Spectral analysis, time-frequency analysis, relation to filter banks. Multirate signal processing, perfect reconstruction filter banks, and connection to wavelets.
A. V. Oppenheim, J. Ward

6.7010 Digital Image Processing
Prereq: 6.3000 and 6.3700
G (Spring)
3-0-9 units

Introduces models, theories, and algorithms key to digital image processing. Core topics covered include models of image formation, image processing fundamentals, filtering in the spatial and frequency domains, image transforms, and feature extraction. Additional topics include image enhancement, image restoration and reconstruction, compression of images and videos, visual recognition, and the application of machine learning-based approaches to image processing. Includes student-driven term project.
Y. Rachlin, J. S. Lim

6.7020 Array Processing
Prereq: 6.7000 and (2.687 or (6.3010 and 18.06))
Acad Year 2023-2024: G (Fall)
Acad Year 2024-2025: Not offered
3-2-7 units

Adaptive and non-adaptive processing of signals received at arrays of sensors. Deterministic beamforming, space-time random processes, optimal and adaptive algorithms, and the sensitivity of algorithm performance to modeling errors and limited data. Methods of improving the robustness of algorithms to modeling errors and limited data are derived. Advanced topics include an introduction to matched field processing and physics-based methods of estimating signal statistics. Homework exercises providing the opportunity to implement and analyze the performance of algorithms in processing data supplied during the course.
J. Bonnel

Control

6.3100 Dynamical System Modeling and Control Design
Subject meets with 6.3102
Prereq: Physics II (GIR) and (18.06 or 18.C06[J])
U (Fall, Spring)
4-4-4 units. Institute LAB

A learn-by-design introduction to modeling and control of discrete- and continuous-time systems, from intuition-building analytical techniques to more computational and data-centric strategies. Topics include: linear difference/differential equations (natural frequencies, transfer functions); controller metrics (stability, tracking, disturbance rejection); analytical techniques (PID, root-loci, lead-lag, phase margin); computational strategies (state-space, eigen-placement, LQR); and data-centric approaches (state estimation, regression, and identification). Concepts are introduced with lectures and online problems, and then mastered during weekly labs. In lab, students model, design, test, and explain systems and controllers involving sensors, actuators, and a microcontroller (e.g., optimizing thrust-driven positioners or stabilizing magnetic levitators). Students taking graduate version complete additional problems and labs.
K. Chen, J. K. White

6.3102 Dynamical System Modeling and Control Design
Subject meets with 6.3100
Prereq: Physics II (GIR) and (18.06 or 18.C06[J])
G (Fall, Spring)
4-4-4 units

A learn-by-design introduction to modeling and control of discrete- and continuous-time systems, from intuition-building analytical techniques to more computational and data-centric strategies. Topics include: linear difference/differential equations (natural frequencies, transfer functions); controller metrics (stability, tracking, disturbance rejection); analytical techniques (PID, root-loci, lead-lag, phase margin); computational strategies (state-space, eigen-placement, LQR); and data-centric approaches (state estimation, regression and identification). Concepts are introduced with lectures and on-line problems, and then mastered during weekly labs. In lab, students model, design, test and explain systems and controllers involving sensors, actuators, and a microcontroller (e.g. optimizing thrust-driven positioners or stabilizing magnetic levitators). Students in the graduate version complete additional problems and labs.
K. Chen, J. K. White

6.7100[J] Dynamic Systems and Control
Same subject as 16.338[J]
Prereq: 6.3000 and 18.06
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Spring)
4-0-8 units

Linear, discrete- and continuous-time, multi-input-output systems in control, related areas. Least squares and matrix perturbation problems. State-space models, modes, stability, controllability, observability, transfer function matrices, poles and zeros, and minimality. Internal stability of interconnected systems, feedback compensators, state feedback, optimal regulation, observers, and observer-based compensators. Measures of control performance, robustness issues using singular values of transfer functions. Introductory ideas on nonlinear systems. Recommended prerequisite: 6.3100.
M. A. Dahleh, A. Megretski

6.7110 Multivariable Control Systems
Prereq: 6.7100[J] or 16.31
G (Fall)
Not offered regularly; consult department
3-0-9 units

Computer-aided design methodologies for synthesis of multivariable feedback control systems. Performance and robustness trade-offs. Model-based compensators; Q-parameterization; ill-posed optimization problems; dynamic augmentation; linear-quadratic optimization of controllers; H-infinity controller design; Mu-synthesis; model and compensator simplification; nonlinear effects. Computer-aided (MATLAB) design homework using models of physical processes.
A. Megretski

6.7120 Principles of Modeling, Computing and Control for Decarbonized Electric Energy Systems (New)
Subject meets with 6.7121
Prereq: 6.2200, (6.2000 and 6.3100), or permission of instructor
U (Fall)
4-0-8 units

Introduces fundamentals of electric energy systems as complex dynamical network systems. Topics include coordinated and distributed modeling and control methods for efficient and reliable power generation, delivery, and consumption; data-enabled algorithms for integrating clean intermittent resources, storage, and flexible demand, including electric vehicles; examples of network congestion management, frequency, and voltage control in electrical grids at various scales; and design and operation of supporting markets. Students taking graduate version complete additional assignments.
M. Ilic

6.7121 Principles of Modeling, Computing and Control for Decarbonized Electric Energy Systems (New)
Subject meets with 6.7120
Prereq: 6.2200, (6.2000 and 6.3100), or permission of instructor
G (Fall)
4-0-8 units

Introduces fundamentals of electric energy systems as complex dynamical network systems. Topics include coordinated and distributed modeling and control methods for efficient and reliable power generation, delivery, and consumption; data-enabled algorithms for integrating clean intermittent resources, storage, and flexible demand, including electric vehicles; examples of network congestion management, frequency, and voltage control in electrical grids at various scales; and design and operation of supporting markets. Students taking graduate version complete additional assignments.
M. Ilic

Optimization & Engineering Mathematics

6.3260[J] Networks
Same subject as 14.15[J]
Subject meets with 14.150
Prereq: 6.3700 or 14.30
U (Spring)
4-0-8 units. HASS-S

See description under subject 14.15[J].
A. Wolitzky

6.7200[J] Optimization Methods
Same subject as 15.093[J], IDS.200[J]
Subject meets with 6.7201
Prereq: 18.06
G (Fall)
4-0-8 units

See description under subject 15.093[J].
D. Bertsimas, P. Parrilo

6.7201 Optimization Methods
Subject meets with 6.7200[J], 15.093[J], IDS.200[J]
Prereq: 18.06
U (Fall)
4-0-8 units

Introduces the principal algorithms for linear, network, discrete, robust, nonlinear, and dynamic optimization. Emphasizes methodology and the underlying mathematical structures. Topics include the simplex method, network flow methods, branch and bound and cutting plane methods for discrete optimization, optimality conditions for nonlinear optimization, interior point methods for convex optimization, Newton's method, heuristic methods, and dynamic programming and optimal control methods. Expectations and evaluation criteria differ for students taking graduate version; consult syllabus or instructor for specific details.
D. Bertsimas, P. Parrilo

6.7210[J] Introduction to Mathematical Programming
Same subject as 15.081[J]
Prereq: 18.06
G (Fall)
4-0-8 units

Introduction to linear optimization and its extensions emphasizing both methodology and the underlying mathematical structures and geometrical ideas. Covers classical theory of linear programming as well as some recent advances in the field. Topics: simplex method; duality theory; sensitivity analysis; network flow problems; decomposition; robust optimization; integer programming; interior point algorithms for linear programming; and introduction to combinatorial optimization and NP-completeness.
J. N. Tsitsiklis, D. Bertsimas

6.7220[J] Nonlinear Optimization
Same subject as 15.084[J]
Prereq: 18.06 and (18.100A, 18.100B, or 18.100Q)
G (Spring)
4-0-8 units

Unified analytical and computational approach to nonlinear optimization problems. Unconstrained optimization methods include gradient, conjugate direction, Newton, sub-gradient and first-order methods. Constrained optimization methods include feasible directions, projection, interior point methods, and Lagrange multiplier methods. Convex analysis, Lagrangian relaxation, nondifferentiable optimization, and applications in integer programming. Comprehensive treatment of optimality conditions and Lagrange multipliers. Geometric approach to duality theory. Applications drawn from control, communications, machine learning, and resource allocation problems.
R. M. Freund, P. Parrilo, G. Perakis

6.7230[J] Algebraic Techniques and Semidefinite Optimization
Same subject as 18.456[J]
Prereq: 6.7210[J] or 15.093[J]
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Spring)
3-0-9 units

Theory and computational techniques for optimization problems involving polynomial equations and inequalities with particular, emphasis on the connections with semidefinite optimization. Develops algebraic and numerical approaches of general applicability, with a view towards methods that simultaneously incorporate both elements, stressing convexity-based ideas, complexity results, and efficient implementations. Examples from several engineering areas, in particular systems and control applications. Topics include semidefinite programming, resultants/discriminants, hyperbolic polynomials, Groebner bases, quantifier elimination, and sum of squares.
P. Parrilo

6.7240 Game Theory with Engineering Applications
Prereq: 6.3702
G (Fall)
Not offered regularly; consult department
4-0-8 units

Introduction to fundamentals of game theory and mechanism design with motivations for each topic drawn from engineering applications (including distributed control of wireline/wireless communication networks, transportation networks, pricing). Emphasis on the foundations of the theory, mathematical tools, as well as modeling and the equilibrium notion in different environments. Topics include normal form games, supermodular games, dynamic games, repeated games, games with incomplete/imperfect information, mechanism design, cooperative game theory, and network games.
A. Ozdaglar

6.7250 Optimization for Machine Learning
Prereq: 6.3900 and 18.06
G (Spring)
3-0-9 units

Optimization algorithms are central to all of machine learning. Covers a variety of topics in optimization, with a focus on non-convex optimization. Focuses on both classical and cutting-edge results, including foundational topics grounded in convexity, complexity theory of first-order methods, stochastic optimization, as well as recent progress in non-Euclidean optimization, deep learning, and beyond. Prepares students to appreciate a broad spectrum of ideas in OPTML, learning to be not only informed users but also gaining exposure to research questions in the area.
S. Sra

6.7260 Network Science and Models
Prereq: 6.3702 and 18.06
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Spring)
3-0-9 units

Introduces the main mathematical models used to describe large networks and dynamical processes that evolve on networks. Static models of random graphs, preferential attachment, and other graph evolution models. Epidemic propagation, opinion dynamics, social learning, and inference in networks. Applications drawn from social, economic, natural, and infrastructure networks, as well as networked decision systems such as sensor networks.
P. Jaillet, J. N. Tsitsiklis

6.7300[J] Introduction to Modeling and Simulation
Same subject as 2.096[J], 16.910[J]
Prereq: 18.03 or 18.06
G (Fall)
3-6-3 units

Introduction to computational techniques for modeling and simulation of a variety of large and complex engineering, science, and socio-economical systems. Prepares students for practical use and development of computational engineering in their own research and future work. Topics include mathematical formulations (e.g., automatic assembly of constitutive and conservation principles); linear system solvers (sparse and iterative); nonlinear solvers (Newton and homotopy); ordinary, time-periodic and partial differential equation solvers; and model order reduction. Students develop their own models and simulators for self-proposed applications, with an emphasis on creativity, teamwork, and communication. Prior basic linear algebra required and at least one numerical programming language (e.g., MATLAB, Julia, Python, etc.) helpful.
L. Daniel

6.7310[J] Introduction to Numerical Methods
Same subject as 18.335[J]
Prereq: 18.06, 18.700, or 18.701
G (Spring)
3-0-9 units

See description under subject 18.335[J].
A. J. Horning

6.7320[J] Parallel Computing and Scientific Machine Learning
Same subject as 18.337[J]
Prereq: 18.06, 18.700, or 18.701
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Spring)
3-0-9 units

See description under subject 18.337[J].
A. Edelman

6.7330[J] Numerical Methods for Partial Differential Equations
Same subject as 2.097[J], 16.920[J]
Prereq: 18.03 or 18.06
G (Fall)
3-0-9 units

See description under subject 16.920[J].
J. Peraire

6.7340[J] Fast Methods for Partial Differential and Integral Equations
Same subject as 18.336[J]
Prereq: 6.7300[J], 16.920[J], 18.085, 18.335[J], or permission of instructor
G (Fall, Spring)
3-0-9 units

See description under subject 18.336[J].
K. Burns

Communications

6.3400 Introduction to EECS via Communication Networks
Prereq: 6.100A
U (Fall)
Not offered regularly; consult department
4-4-4 units. Institute LAB

Studies key concepts, systems, and algorithms to reliably communicate data in settings ranging from the cellular phone network and the Internet to deep space. Weekly laboratory experiments explore these areas in depth. Topics presented in three modules - bits, signals, and packets - spanning the multiple layers of a communication system. Bits module includes information, entropy, data compression algorithms, and error correction with block and convolutional codes. Signals module includes modeling physical channels and noise, signal design, filtering and detection, modulation, and frequency-division multiplexing. Packets module includes switching and queuing principles, media access control, routing protocols, and data transport protocols.
K. LaCurts

6.7410 Principles of Digital Communication
Subject meets with 6.7411
Prereq: (6.3000 or 6.3102) and (6.3700, 6.3800, or 18.05)
G (Fall)
3-0-9 units

Covers communications by progressing through signal representation, sampling, quantization, compression, modulation, coding and decoding, medium access control, and queueing and principles of protocols. By providing simplified proofs, seeks to present an integrated, systems-level view of networking and communications while laying the foundations of analysis and design. Lectures are offered online; in-class time is dedicated to recitations, exercises, and weekly group labs. Homework exercises are based on theoretical derivation and software implementation. Students taking graduate version complete additional assignments.
M. Medard

6.7411 Principles of Digital Communication
Subject meets with 6.7410
Prereq: (6.3000, 6.3100, or 6.3400) and (6.3700, 6.3800, or 18.05)
U (Fall)
3-0-9 units

Covers communications by progressing through signal representation, sampling, quantization, compression, modulation, coding and decoding, medium access control, and queueing and principles of protocols. By providing simplified proofs, seeks to present an integrated, systems-level view of networking and communications while laying the foundations of analysis and design. Lectures are offered online; in-class time is dedicated to recitations, exercises, and weekly group labs. Homework exercises are based on theoretical derivation and software implementation. Students taking graduate version complete additional assignments.
M. Medard

6.7420 Heterogeneous Networks: Architecture, Transport, Proctocols, and Management
Prereq: 6.1200[J] or 6.3700
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Fall)
4-0-8 units

Introduction to modern heterogeneous networks and the provision of heterogeneous services. Architectural principles, analysis, algorithmic techniques, performance analysis, and existing designs are developed and applied to understand current problems in network design and architecture. Begins with basic principles of networking. Emphasizes development of mathematical and algorithmic tools; applies them to understanding network layer design from the performance and scalability viewpoint. Concludes with network management and control, including the architecture and performance analysis of interconnected heterogeneous networks. Provides background and insight to understand current network literature and to perform research on networks with the aid of network design projects.
V. W. S. Chan, R. G. Gallager

6.7430 Optical Networks
Prereq: 6.1200[J] or 6.3700
Acad Year 2023-2024: G (Spring)
Acad Year 2024-2025: Not offered
3-0-9 units

Introduces the fundamental and practical aspects of optical network technology, architecture, design and analysis tools and techniques. The treatment of optical networks are from the architecture and system design points of view. Optical hardware technologies are introduced and characterized as fundamental network building blocks on which optical transmission systems and network architectures are based. Beyond the Physical Layer, the higher network layers (Media Access Control, Network and Transport Layers) are treated together as integral parts of network design. Performance metrics, analysis and optimization techniques are developed to help guide the creation of high performance complex optical networks.
V. W. S. Chan

6.7440 Principles of Wireless Communication
Prereq: 6.7410
G (Fall)
Not offered regularly; consult department
3-0-9 units

Introduction to design, analysis, and fundamental limits of wireless transmission systems. Wireless channel and system models; fading and diversity; resource management and power control; multiple-antenna and MIMO systems; space-time codes and decoding algorithms; multiple-access techniques and multiuser detection; broadcast codes and precoding; cellular and ad-hoc network topologies; OFDM and ultrawideband systems; architectural issues.
G. W. Wornell, L. Zheng

6.7450[J] Data-Communication Networks
Same subject as 16.37[J]
Prereq: 6.3700 or 18.204
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Fall)
3-0-9 units

Provides an introduction to data networks with an analytic perspective, using wireless networks, satellite networks, optical networks, the internet and data centers as primary applications. Presents basic tools for modeling and performance analysis. Draws upon concepts from stochastic processes, queuing theory, and optimization.
E. Modiano

6.7460 Essential Coding Theory
Prereq: 6.1210 and 6.1400[J]
G (Spring)
Not offered regularly; consult department
3-0-9 units

Introduces the theory of error-correcting codes. Focuses on the essential results in the area, taught from first principles. Special focus on results of asymptotic or algorithmic significance. Principal topics include construction and existence results for error-correcting codes; limitations on the combinatorial performance of error-correcting codes; decoding algorithms; and applications to other areas of mathematics and computer science.
Staff

6.7470 Information Theory
Prereq: 6.3700
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Fall)
3-0-9 units

Mathematical definitions of information measures, convexity, continuity, and variational properties. Lossless source coding; variable-length and block compression; Slepian-Wolf theorem; ergodic sources and Shannon-McMillan theorem. Hypothesis testing, large deviations and I-projection. Fundamental limits of block coding for noisy channels: capacity, dispersion, finite blocklength bounds. Coding with feedback. Joint source-channel problem. Rate-distortion theory, vector quantizers. Advanced topics include Gelfand-Pinsker problem, multiple access channels, broadcast channels (depending on available time).
M. Medard, Y. Polyanskiy, L. Zheng

Probability & Statistics

6.3700 Introduction to Probability
Subject meets with 6.3702
Prereq: Calculus II (GIR)
U (Fall, Spring)
4-0-8 units. REST
Credit cannot also be received for 18.600

An introduction to probability theory, the modeling and analysis of probabilistic systems, and elements of statistical inference. Probabilistic models, conditional probability. Discrete and continuous random variables. Expectation and conditional expectation, and further topics about random variables. Limit Theorems. Bayesian estimation and hypothesis testing. Elements of classical statistical inference. Bernoulli and Poisson processes. Markov chains. Students taking graduate version complete additional assignments.
G. Bresler, P. Jaillet, J. N. Tsitsiklis

6.3702 Introduction to Probability
Subject meets with 6.3700
Prereq: Calculus II (GIR)
G (Fall, Spring)
4-0-8 units
Credit cannot also be received for 18.600

An introduction to probability theory, the modeling and analysis of probabilistic systems, and elements of statistical inference. Probabilistic models, conditional probability. Discrete and continuous random variables. Expectation and conditional expectation, and further topics about random variables. Limit Theorems. Bayesian estimation and hypothesis testing. Elements of classical statistical inference. Bernoulli and Poisson processes. Markov chains. Students taking graduate version complete additional assignments.
G. Bresler, P. Jaillet, J. N. Tsitsiklis

6.3720 Introduction to Statistical Data Analysis
Subject meets with 6.3722
Prereq: 6.100A and (6.3700, 6.3800, or 18.600)
U (Spring)
4-0-8 units

Introduction to the central concepts and methods of data science with an emphasis on statistical grounding and modern computational capabilities. Covers principles involved in extracting information from data for the purpose of making predictions or decisions, including data exploration, feature selection, model fitting, and performance assessment. Topics include learning of distributions, hypothesis testing (including multiple comparison procedures), linear and nonlinear regression and prediction, classification, time series, uncertainty quantification, model validation, causal inference, optimization, and decisions. Computational case studies and projects drawn from applications in finance, sports, engineering, and machine learning life sciences. Students taking graduate version complete additional assignments. Recommended prerequisite: 18.06.
Y. Polyanskiy, D. Shah, J. N. Tsitsiklis

6.3722 Introduction to Statistical Data Analysis
Subject meets with 6.3720
Prereq: 6.100A and (6.3700, 6.3800, 18.600, or permission of instructor)
G (Spring)
4-0-8 units

Introduction to the central concepts and methods of data science with an emphasis on statistical grounding and modern computational capabilities. Covers principles involved in extracting information from data for the purpose of making predictions or decisions, including data exploration, feature selection, model fitting, and performance assessment. Topics include learning of distributions, hypothesis testing (including multiple comparison procedures), linear and nonlinear regression and prediction, classification, time series, uncertainty quantification, model validation, causal inference, optimization, and decisions. Computational case studies and projects drawn from applications in finance, sports, engineering, and machine learning life sciences. Students taking graduate version complete additional assignments. Recommended prerequisite: 18.06.
Y. Polyanskiy, D. Shah, J. N. Tsitsiklis

6.3730[J] Statistics, Computation and Applications
Same subject as IDS.012[J]
Subject meets with 6.3732[J], IDS.131[J]
Prereq: (6.100B, (18.03, 18.06, or 18.C06[J]), and (6.3700, 6.3800, 14.30, 16.09, or 18.05)) or permission of instructor
U (Spring)
3-1-8 units

See description under subject IDS.012[J]. Enrollment limited; priority to Statistics and Data Science minors, and to juniors and seniors.
C. Uhler, N. Azizan

6.3732[J] Statistics, Computation and Applications
Same subject as IDS.131[J]
Subject meets with 6.3730[J], IDS.012[J]
Prereq: (6.100B, (18.03, 18.06, or 18.C06[J]), and (6.3700, 6.3800, 14.30, 16.09, or 18.05)) or permission of instructor
G (Spring)
3-1-8 units

See description under subject IDS.131[J]. Limited enrollment; priority to Statistics and Data Science minors and to juniors and seniors.
C. Uhler, N. Azizan

6.7700[J] Fundamentals of Probability
Same subject as 15.085[J]
Prereq: Calculus II (GIR)
G (Fall)
4-0-8 units

Introduction to probability theory. Probability spaces and measures. Discrete and continuous random variables. Conditioning and independence. Multivariate normal distribution. Abstract integration, expectation, and related convergence results. Moment generating and characteristic functions. Bernoulli and Poisson process. Finite-state Markov chains. Convergence notions and their relations. Limit theorems. Familiarity with elementary probability and real analysis is desirable.
T. Broderick, D. Gamarnik, Y. Polyanskiy, J. N. Tsitsiklis

6.7710 Discrete Stochastic Processes
Prereq: 6.3702 or 18.204
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Spring)
4-0-8 units

Review of probability and laws of large numbers; Poisson counting process and renewal processes; Markov chains (including Markov decision theory), branching processes, birth-death processes, and semi-Markov processes; continuous-time Markov chains and reversibility; random walks, martingales, and large deviations; applications from queueing, communication, control, and operations research.
R. G. Gallager, V. W. S. Chan

6.7720[J] Discrete Probability and Stochastic Processes
Same subject as 15.070[J], 18.619[J]
Prereq: 6.3702, 6.7700[J], 18.100A, 18.100B, or 18.100Q
G (Spring)
3-0-9 units

See description under subject 15.070[J].
G. Bresler, D. Gamarnik, E. Mossel, Y. Polyanskiy

Inference

6.3800 Introduction to Inference
Prereq: Calculus II (GIR) or permission of instructor
U (Fall)
4-4-4 units. Institute LAB

Introduces probabilistic modeling for problems of inference and machine learning from data, emphasizing analytical and computational aspects. Distributions, marginalization, conditioning, and structure, including graphical and neural network representations. Belief propagation, decision-making, classification, estimation, and prediction. Sampling methods and analysis. Introduces asymptotic analysis and information measures. Computational laboratory component explores the concepts introduced in class in the context of contemporary applications. Students design inference algorithms, investigate their behavior on real data, and discuss experimental results.
P. Golland, G. W. Wornell

6.7800 Inference and Information
Prereq: 6.3700, 6.3800, or 6.7700[J]
G (Spring)
4-0-8 units

Introduction to principles of Bayesian and non-Bayesian statistical inference. Hypothesis testing and parameter estimation, sufficient statistics; exponential families. EM agorithm. Log-loss inference criterion, entropy and model capacity. Kullback-Leibler distance and information geometry. Asymptotic analysis and large deviations theory. Model order estimation; nonparametric statistics. Computational issues and approximation techniques; Monte Carlo methods. Selected topics such as universal inference and learning, and universal features and neural networks.
P. Golland, G. W. Wornell

6.7810 Algorithms for Inference
Prereq: 18.06 and (6.3700, 6.3800, or 6.7700[J])
G (Fall)
4-0-8 units

Introduction to statistical inference with probabilistic graphical models. Directed and undirected graphical models, and factor graphs, over discrete and Gaussian distributions; hidden Markov models, linear dynamical systems. Sum-product and junction tree algorithms; forward-backward algorithm, Kalman filtering and smoothing. Min-sum and Viterbi algorithms. Variational methods, mean-field theory, and loopy belief propagation. Particle methods and filtering. Building graphical models from data, including parameter estimation and structure learning; Baum-Welch and Chow-Liu algorithms. Selected special topics.
P. Golland, G. W. Wornell, D. Shah

6.7820[J] Graphical Models: A Geometric, Algebraic, and Combinatorial Perspective
Same subject as IDS.136[J]
Prereq: 6.3702 and 18.06
G (Fall)
Not offered regularly; consult department
3-0-9 units

See description under subject IDS.136[J].
C. Uhler

6.7830 Bayesian Modeling and Inference
Prereq: 6.7700[J] and 6.7900
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Spring)
3-0-9 units

Covers Bayesian modeling and inference at an advanced graduate level. Topics include de Finetti's theorem, decision theory, approximate inference (modern approaches and analysis of Monte Carlo, variational inference, etc.), hierarchical modeling, (continuous and discrete) nonparametric Bayesian approaches, sensitivity and robustness, and evaluation.
T. Broderick

Machine Learning

6.3900 Introduction to Machine Learning
Prereq: (6.1010 or 6.1210) and (18.06, 18.700, or 18.C06[J])
U (Fall, Spring)
4-0-8 units

Introduces principles, algorithms, and applications of machine learning from the point of view of modeling and prediction; formulation of learning problems; representation, over-fitting, generalization; clustering, classification, probabilistic modeling; and methods such as support vector machines, hidden Markov models, and neural networks. Recommended prerequisites: 6.1210 and 18.06. Enrollment may be limited.
D. S. Boning, P. Jaillet, L. P. Kaelbling

6.3950 AI, Decision Making, and Society
Subject meets with 6.3952
Prereq: None. *Coreq: 6.1200[J], 6.3700, 6.3800, 18.05, or 18.600*
U (Fall)
4-0-8 units

Introduction to fundamentals of modern data-driven decision-making frameworks, such as causal inference and hypothesis testing in statistics as well as supervised and reinforcement learning in machine learning. Explores how these frameworks are being applied in various societal contexts, including criminal justice, healthcare, finance, and social media. Emphasis on pinpointing the non-obvious interactions, undesirable feedback loops, and unintended consequences that arise in such settings. Enables students to develop their own principled perspective on the interface of data-driven decision making and society. Students taking graduate version complete additional assignments.
A. Ozdaglar, A. Madry, A. Wilson

6.3952 AI, Decision Making, and Society
Subject meets with 6.3950
Prereq: None. *Coreq: 6.1200[J], 6.3700, 6.3800, or 18.05*
G (Fall)
4-0-8 units

Introduction to fundamentals of modern data-driven decision-making frameworks, such as causal inference and hypothesis testing in statistics as well as supervised and reinforcement learning in machine learning. Explores how these frameworks are being applied in various societal contexts, including criminal justice, healthcare, finance, and social media. Emphasis on pinpointing the non-obvious interactions, undesirable feedback loops, and unintended consequences that arise in such settings. Enables students to develop their own principled perspective on the interface of data-driven decision making and society. Students taking graduate version complete additional assignments.
A. Ozdaglar, A. Madry, A. Wilson

6.7900 Machine Learning
Prereq: 18.06 and (6.3700, 6.3800, or 18.600)
G (Fall)
3-0-9 units

Principles, techniques, and algorithms in machine learning from the point of view of statistical inference; representation, generalization, and model selection; and methods such as linear/additive models, active learning, boosting, support vector machines, non-parametric Bayesian methods, hidden Markov models, Bayesian networks, and convolutional and recurrent neural networks. Recommended prerequisite: 6.3900 or other previous experience in machine learning. Enrollment may be limited.
C. Daskalakis, T. Jaakkola

6.7910[J] Statistical Learning Theory and Applications
Same subject as 9.520[J]
Prereq: 6.3700, 6.7900, 18.06, or permission of instructor
G (Fall)
3-0-9 units

See description under subject 9.520[J].
T. Poggio, L. Rosasco

6.7920[J] Reinforcement Learning: Foundations and Methods (New)
Same subject as 1.127[J], IDS.140[J]
Prereq: 6.3700 or permission of instructor
G (Fall)
4-0-8 units

Examines reinforcement learning (RL) as a methodology for approximately solving sequential decision-making under uncertainty, with foundations in optimal control and machine learning. Provides a mathematical introduction to RL, including dynamic programming, statistical, and empirical perspectives, and special topics. Core topics include: dynamic programming, special structures, finite and infinite horizon Markov Decision Processes, value and policy iteration, Monte Carlo methods, temporal differences, Q-learning, stochastic approximation, and bandits. Also covers approximate dynamic programming, including value-based methods and policy space methods. Applications and examples drawn from diverse domains. Focus is mathematical, but is supplemented with computational exercises. An analysis prerequisite is suggested but not required; mathematical maturity is necessary.
C. Wu

6.7930[J] Machine Learning for Healthcare
Same subject as HST.956[J]
Prereq: 6.3900, 6.4100, 6.7810, 6.7900, 6.8611, or 9.520[J]
G (Spring)
4-0-8 units

Introduces students to machine learning in healthcare, including the nature of clinical data and the use of machine learning for risk stratification, disease progression modeling, precision medicine, diagnosis, subtype discovery, and improving clinical workflows. Topics include causality, interpretability, algorithmic fairness, time-series analysis, graphical models, deep learning and transfer learning. Guest lectures by clinicians from the Boston area, and projects with real clinical data, emphasize subtleties of working with clinical data and translating machine learning into clinical practice. Limited to 55.
D. Sontag, P. Szolovits

6.7940 Dynamic Programming and Reinforcement Learning
Prereq: 6.3700 or 18.600
G (Spring)
Not offered regularly; consult department
4-0-8 units

Dynamic programming as a unifying framework for sequential decision-making under uncertainty, Markov decision problems, and stochastic control. Perfect and imperfect state information models. Finite horizon and infinite horizon problems, including discounted and average cost formulations. Value and policy iteration. Suboptimal methods. Approximate dynamic programming for large-scale problems, and reinforcement learning. Applications and examples drawn from diverse domains. While an analysis prerequisite is not required, mathematical maturity is necessary.
J. N. Tsitsiklis

6.7950 Advanced Topics in Control
Prereq: Permission of instructor
G (Fall)
Not offered regularly; consult department
3-0-9 units
Can be repeated for credit.

Advanced study of topics in control. Specific focus varies from year to year.
Consult Department

Artificial Intelligence

6.4100 Artificial Intelligence
Prereq: 6.100A
U (Fall)
Not offered regularly; consult department
4-3-5 units

Introduces representations, methods, and architectures used to build applications and to account for human intelligence from a computational point of view. Covers applications of rule chaining, constraint propagation, constrained search, inheritance, statistical inference, and other problem-solving paradigms. Also addresses applications of identification trees, neural nets, genetic algorithms, support-vector machines, boosting, and other learning paradigms. Considers what separates human intelligence from that of other animals.
Staff

6.4102 Artificial Intelligence
Prereq: 6.100A
G (Fall)
Not offered regularly; consult department
4-3-5 units

Introduces representations, methods, and architectures used to build applications and to account for human intelligence from a computational point of view. Covers applications of rule chaining, constraint propagation, constrained search, inheritance, statistical inference, and other problem-solving paradigms. Also addresses applications of identification trees, neural nets, genetic algorithms, support-vector machines, boosting, and other learning paradigms. Considers what separates human intelligence from that of other animals. Students taking graduate version complete additional assignments.
K. Koile

6.4110 Representation, Inference, and Reasoning in AI
Subject meets with 16.420
Prereq: (16.09 and 16.410[J]) or (6.1010, 6.1210, and (6.3700 or 6.3800))
U (Fall)
3-0-9 units

An introduction to representations and algorithms for artificial intelligence. Topics covered include: constraint satisfaction in discrete and continuous problems, logical representation and inference, Monte Carlo tree search, probabilistic graphical models and inference, planning in discrete and continuous deterministic and probabilistic models including MDPs and POMDPs.
L. P. Kaelbling, T. Lozano-Perez, N. Roy

6.4120[J] Computational Cognitive Science
Same subject as 9.66[J]
Subject meets with 9.660
Prereq: 6.3700, 6.3800, 9.40, 18.05, 6.3900, or permission of instructor
U (Fall)
3-0-9 units

See description under subject 9.66[J].
J. Tenenbaum

6.4130[J] Principles of Autonomy and Decision Making
Same subject as 16.410[J]
Subject meets with 6.4132[J], 16.413[J]
Prereq: 6.100B or 6.9080
U (Fall)
4-0-8 units

See description under subject 16.410[J].
H. E. Shrobe

6.4132[J] Principles of Autonomy and Decision Making
Same subject as 16.413[J]
Subject meets with 6.4130[J], 16.410[J]
Prereq: 6.100B, 6.9080, or permission of instructor
G (Fall)
3-0-9 units

See description under subject 16.413[J].
B. C. Williams

6.4150[J] Artificial Intelligence for Business (New)
Same subject as 15.563[J]
Prereq: None
G (Spring)
3-0-6 units

See description under subject 15.563[J].
M. Raghavan

6.8110[J] Cognitive Robotics
Same subject as 16.412[J]
Prereq: (6.4100 or 16.413[J]) and (6.1200[J], 6.3700, or 16.09)
G (Spring)
3-0-9 units

See description under subject 16.412[J]. Enrollment may be limited.
B. C. Williams

Robotics

6.4200[J] Robotics: Science and Systems
Same subject as 2.124[J], 16.405[J]
Prereq: ((1.00 or 6.100A) and (2.003[J], 6.1010, 6.1210, or 16.06)) or permission of instructor
U (Spring)
2-6-4 units. Institute LAB

Presents concepts, principles, and algorithmic foundations for robots and autonomous vehicles operating in the physical world. Topics include sensing, kinematics and dynamics, state estimation, computer vision, perception, learning, control, motion planning, and embedded system development. Students design and implement advanced algorithms on complex robotic platforms capable of agile autonomous navigation and real-time interaction with the physical word. Students engage in extensive written and oral communication exercises. Enrollment limited.
L. Carlone, S. Karaman, D. Hadfield-Manell, J. Leonard

6.4210 Robotic Manipulation
Subject meets with 6.4212
Prereq: (6.100A and 6.3900) or permission of instructor
U (Fall)
4-2-9 units

Introduces the fundamental algorithmic approaches for creating robot systems that can autonomously manipulate physical objects in unstructured environments such as homes and restaurants. Topics include perception (including approaches based on deep learning and approaches based on 3D geometry), planning (robot kinematics and trajectory generation, collision-free motion planning, task-and-motion planning, and planning under uncertainty), as well as dynamics and control (both model-based and learning-based). Students taking graduate version complete additional assignments. Students engage in extensive written and oral communication exercises.
R. Tedrake

6.4212 Robotic Manipulation
Subject meets with 6.4210
Prereq: (6.100A and 6.3900) or permission of instructor
G (Fall)
3-0-9 units

Introduces the fundamental algorithmic approaches for creating robot systems that can autonomously manipulate physical objects in unstructured environments such as homes and restaurants. Topics include perception (including approaches based on deep learning and approaches based on 3D geometry), planning (robot kinematics and trajectory generation, collision-free motion planning, task-and-motion planning, and planning under uncertainty), as well as dynamics and control (both model-based and learning-based. Students taking graduate version complete additional assignments.
T. P. Lozano-Perez, R. Tedrake

6.8200 Sensorimotor Learning
Prereq: 6.3900 or 6.7900
G (Spring)
3-0-9 units

Provides an in-depth view of the state-of-the-art learning methods for control and the know-how of applying these techniques. Topics span reinforcement learning, self-supervised learning, imitation learning, model-based learning, and advanced deep learning architectures, and specific machine learning challenges unique to building sensorimotor systems. Discusses how to identify if learning-based control can help solve a particular problem, how to formulate the problem in the learning framework, and what algorithm to use. Applications of algorithms in robotics, logistics, recommendation systems, playing games, and other control domains covered. Instruction involves two lectures a week, practical experience through exercises, discussion of current research directions, and a group project.
P. Agrawal

6.8210 Underactuated Robotics
Prereq: 18.03 and 18.06
G (Spring)
3-0-9 units

Covers nonlinear dynamics and control of underactuated mechanical systems, with an emphasis on computational methods. Topics include the nonlinear dynamics of robotic manipulators, applied optimal and robust control and motion planning. Discussions include examples from biology and applications to legged locomotion, compliant manipulation, underwater robots, and flying machines.
R. Tedrake

Graphics

6.4400 Computer Graphics
Prereq: 6.1010 and (18.06 or 18.C06[J])
U (Fall)
3-0-9 units

Introduction to computer graphics algorithms, software and hardware. Topics include ray tracing, the graphics pipeline, transformations, texture mapping, shadows, sampling, global illumination, splines, animation and color.
F. P. Durand, W. Matusik, J. Solomon

6.4420[J] Computational Design and Fabrication
Same subject as 2.0911[J]
Subject meets with 6.8420
Prereq: Calculus II (GIR) and (6.1010 or permission of instructor)
U (Spring)
3-0-9 units

Introduces computational aspects of computer-aided design and manufacturing. Explores relevant methods in the context of additive manufacturing (e.g., 3D printing). Topics include computer graphics (geometry modeling, solid modeling, procedural modeling), physically-based simulation (kinematics, finite element method), 3D scanning/geometry processing, and an overview of 3D fabrication methods. Exposes students to the latest research in computational fabrication. Students taking the graduate version complete additional assignments.
W. Matusik

6.8410 Shape Analysis
Prereq: Calculus II (GIR), 18.06, and (6.8300 or 6.4400)
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Spring)
3-0-9 units

Introduces mathematical, algorithmic, and statistical tools needed to analyze geometric data and to apply geometric techniques to data analysis, with applications to fields such as computer graphics, machine learning, computer vision, medical imaging, and architecture. Potential topics include applied introduction to differential geometry, discrete notions of curvature, metric embedding, geometric PDE via the finite element method (FEM) and discrete exterior calculus (DEC),; computational spectral geometry and relationship to graph-based learning, correspondence and mapping, level set method, descriptor, shape collections, optimal transport, and vector field design.
J. Solomon

6.8420 Computational Design and Fabrication
Subject meets with 2.0911[J], 6.4420[J]
Prereq: Calculus II (GIR) and (6.1010 or permission of instructor)
G (Spring)
3-0-9 units

Introduces computational aspects of computer-aided design and manufacturing. Explores relevant methods in the context of additive manufacturing (e.g., 3D printing). Topics include computer graphics (geometry modeling, solid modeling, procedural modeling), physically-based simulation (kinematics, finite element method), 3D scanning/geometry processing, and an overview of 3D fabrication methods. Exposes students to the latest research in computational fabrication. Students taking graduate version complete additional assignments.
W. Matusik

Human-Computer Interaction & Society

6.4510 Engineering Interactive Technologies
Prereq: 6.1020, 6.2050, 6.2060, 6.9010, or permission of instructor
U (Fall)
Not offered regularly; consult department
1-5-6 units

Provides instruction in building cutting-edge interactive technologies, explains the underlying engineering concepts, and shows how those technologies evolved over time. Students use a studio format (i.e., extended periods of time) for constructing software and hardware prototypes. Topics include interactive technologies, such as multi-touch, augmented reality, haptics, wearables, and shape-changing interfaces. In a group project, students build their own interactive hardware/software prototypes and present them in a live demo at the end of term. Enrollment may be limited.
S. Mueller

6.4530[J] Principles and Practice of Assistive Technology
Same subject as 2.78[J], HST.420[J]
Prereq: Permission of instructor
U (Fall)
Not offered regularly; consult department
2-4-6 units

Students work closely with people with disabilities to develop assistive and adaptive technologies that help them live more independently. Covers design methods and problem-solving strategies; human factors; human-machine interfaces; community perspectives; social and ethical aspects; and assistive technology for motor, cognitive, perceptual, and age-related impairments. Prior knowledge of one or more of the following areas useful: software; electronics; human-computer interaction; cognitive science; mechanical engineering; control; or MIT hobby shop, MIT PSC, or other relevant independent project experience. Enrollment may be limited.
R. C. Miller, J. E. Greenberg, J. J. Leonard

6.4550[J] Interactive Music Systems
Same subject as 21M.385[J]
Subject meets with 21M.585
Prereq: (6.1010 and 21M.301) or permission of instructor
U (Fall, Spring)
3-0-9 units. HASS-A

See description under subject 21M.385[J]. Limited to 36.
E. Egozy, L. Kaelbling

6.4570[J] Creating Video Games
Same subject as CMS.611[J]
Prereq: 6.100A or CMS.301
U (Fall)
3-3-6 units. HASS-A

See description under subject CMS.611[J]. Limited to 36.
P. Tan, S. Verrilli, R. Eberhardt, A. Grant

6.4590[J] Foundations of Information Policy
Same subject as STS.085[J]
Subject meets with STS.487
Prereq: Permission of instructor
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: U (Fall)
3-0-9 units. HASS-S

Studies the growth of computer and communications technology and the new legal and ethical challenges that reflect tensions between individual rights and societal needs. Topics include computer crime; intellectual property restrictions on software; encryption, privacy, and national security; academic freedom and free speech. Students meet and question technologists, activists, law enforcement agents, journalists, and legal experts. Instruction and practice in oral and written communication provided. Students taking graduate version complete additional assignments. Enrollment limited.
H. Abelson, M. Fischer, D. Weitzner

6.8510 Intelligent Multimodal User Interfaces
Prereq: (6.1020 and 6.4100) or permission of instructor
G (Spring)
3-0-9 units

Implementation and evaluation of intelligent multi-modal user interfaces, taught from a combination of hands-on exercises and papers from the original literature. Topics include basic technologies for handling speech, vision, pen-based interaction, and other modalities, as well as various techniques for combining modalities. Substantial readings and a term project, where students build a program that illustrates one or more of the themes of the course.
R. Davis

6.8530 Interactive Data Visualization
Prereq: 6.1020
G (Spring)
3-0-9 units
Credit cannot also be received for 6.C35[J], 6.C85[J], 11.154, 11.454, 11.C35[J], 11.C85[J]

Interactive visualization provides a means of making sense of a world awash in data. Covers the techniques and algorithms for creating effective visualizations, using principles from graphic design, perceptual psychology, and cognitive science. Short assignments build familiarity with the data analysis and visualization design process, and a final project provides experience designing, implementing, and deploying an explanatory narrative visualization or visual analysis tool to address a concrete challenge.
A. Satyanarayan

Computational Biology

6.4710[J] Evolutionary Biology: Concepts, Models and Computation
Same subject as 7.33[J]
Prereq: (6.100A and 7.03) or permission of instructor
U (Spring)
3-0-9 units

See description under subject 7.33[J].
R. Berwick, D. Bartel

6.8700[J] Advanced Computational Biology: Genomes, Networks, Evolution
Same subject as HST.507[J]
Subject meets with 6.8701
Prereq: (Biology (GIR), 6.1210, and 6.3700) or permission of instructor
G (Fall)
4-0-8 units

See description for 6.047. Additionally examines recent publications in the areas covered, with research-style assignments. A more substantial final project is expected, which can lead to a thesis and publication.
M. Kellis

6.8701 Computational Biology: Genomes, Networks, Evolution
Subject meets with 6.8700[J], HST.507[J]
Prereq: (Biology (GIR), 6.1210, and 6.3700) or permission of instructor
U (Fall)
3-0-9 units

Covers the algorithmic and machine learning foundations of computational biology, combining theory with practice. Principles of algorithm design, influential problems and techniques, and analysis of large-scale biological datasets. Topics include (a) genomes: sequence analysis, gene finding, RNA folding, genome alignment and assembly, database search; (b) networks: gene expression analysis, regulatory motifs, biological network analysis; (c) evolution: comparative genomics, phylogenetics, genome duplication, genome rearrangements, evolutionary theory. These are coupled with fundamental algorithmic techniques including: dynamic programming, hashing, Gibbs sampling, expectation maximization, hidden Markov models, stochastic context-free grammars, graph clustering, dimensionality reduction, Bayesian networks.
M. Kellis

6.8710[J] Computational Systems Biology: Deep Learning in the Life Sciences
Same subject as HST.506[J]
Subject meets with 6.8711[J], 20.390[J], 20.490
Prereq: Biology (GIR) and (6.3700 or 18.600)
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Spring)
3-0-9 units

Presents innovative approaches to computational problems in the life sciences, focusing on deep learning-based approaches with comparisons to conventional methods. Topics include protein-DNA interaction, chromatin accessibility, regulatory variant interpretation, medical image understanding, medical record understanding, therapeutic design, and experiment design (the choice and interpretation of interventions). Focuses on machine learning model selection, robustness, and interpretation. Teams complete a multidisciplinary final research project using TensorFlow or other framework. Provides a comprehensive introduction to each life sciences problem, but relies upon students understanding probabilistic problem formulations. Students taking graduate version complete additional assignments.
D. K. Gifford

6.8711[J] Computational Systems Biology: Deep Learning in the Life Sciences
Same subject as 20.390[J]
Subject meets with 6.8710[J], 20.490, HST.506[J]
Prereq: (7.05 and (6.100B or 6.9080)) or permission of instructor
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: U (Spring)
3-0-9 units

Presents innovative approaches to computational problems in the life sciences, focusing on deep learning-based approaches with comparisons to conventional methods. Topics include protein-DNA interaction, chromatin accessibility, regulatory variant interpretation, medical image understanding, medical record understanding, therapeutic design, and experiment design (the choice and interpretation of interventions). Focuses on machine learning model selection, robustness, and interpretation. Teams complete a multidisciplinary final research project using TensorFlow or other framework. Provides a comprehensive introduction to each life sciences problem, but relies upon students understanding probabilistic problem formulations. Students taking graduate version complete additional assignments.
D. K. Gifford

6.8720[J] Principles of Synthetic Biology
Same subject as 20.405[J]
Subject meets with 6.8721[J], 20.305[J]
Prereq: None
G (Fall)
3-0-9 units

See description under subject 20.405[J].
R. Weiss

6.8721[J] Principles of Synthetic Biology
Same subject as 20.305[J]
Subject meets with 6.8720[J], 20.405[J]
Prereq: None
U (Fall)
3-0-9 units

See description under subject 20.305[J].
R. Weiss

Biomedical & Health

6.4800[J] Biomedical Systems: Modeling and Inference
Same subject as 22.54[J]
Prereq: (6.3100 and (18.06 or 18.C06[J])) or permission of instructor
U (Spring)
4-4-4 units

Medically motivated examples of problems in human health that engage students in systems modeling, signal analysis and inference, and design. Content draws on two domains, first by establishing a model of the human cardiovascular system with signal analysis and inference applications of electrocardiograms in health and disease. In a second topic, medical imaging by MRI is motivated by examples of common clinical decision making, followed by laboratory work with technology and instrumentation with the functionality of commercial diagnostic scanners. Students apply concepts from lectures in labs for data collection for image reconstruction, image analysis, and inference by their own design. Labs further include kits for interactive and portable low-cost devices that can be assembled by the students to demonstrate fundamental building blocks of an MRI system.
E. Adalsteinsson, T. Heldt, C. M. Stultz, J. K. White

6.4810[J] Cellular Neurophysiology and Computing
Same subject as 2.791[J], 9.21[J], 20.370[J]
Subject meets with 2.794[J], 6.4812[J], 9.021[J], 20.470[J], HST.541[J]
Prereq: (Physics II (GIR), 18.03, and (2.005, 6.2000, 6.3000, 10.301, or 20.110[J])) or permission of instructor
U (Spring)
5-2-5 units

Integrated overview of the biophysics of cells from prokaryotes to neurons, with a focus on mass transport and electrical signal generation across cell membrane. First third of course focuses on mass transport through membranes: diffusion, osmosis, chemically mediated, and active transport. Second third focuses on electrical properties of cells: ion transport to action potential generation and propagation in electrically excitable cells. Synaptic transmission. Electrical properties interpreted via kinetic and molecular properties of single voltage-gated ion channels. Final third focuses on biophysics of synaptic transmission and introduction to neural computing. Laboratory and computer exercises illustrate the concepts. Students taking graduate version complete different assignments. Preference to juniors and seniors.
J. Han, T. Heldt

6.4812[J] Cellular Neurophysiology and Computing
Same subject as 2.794[J], 9.021[J], 20.470[J], HST.541[J]
Subject meets with 2.791[J], 6.4810[J], 9.21[J], 20.370[J]
Prereq: (Physics II (GIR), 18.03, and (2.005, 6.2000, 6.3000, 10.301, or 20.110[J])) or permission of instructor
G (Spring)
5-2-5 units

Integrated overview of the biophysics of cells from prokaryotes to neurons, with a focus on mass transport and electrical signal generation across cell membrane. First third of course focuses on mass transport through membranes: diffusion, osmosis, chemically mediated, and active transport. Second third focuses on electrical properties of cells: ion transport to action potential generation and propagation in electrically excitable cells. Synaptic transmission. Electrical properties interpreted via kinetic and molecular properties of single voltage-gated ion channels. Final third focuses on biophysics of synaptic transmission and introduction to neural computing. Laboratory and computer exercises illustrate the concepts. Students taking graduate version complete different assignments.
J. Han, T. Heldt

6.4820[J] Quantitative and Clinical Physiology
Same subject as 2.792[J], HST.542[J]
Subject meets with 2.796[J], 6.4822[J]
Prereq: Physics II (GIR), 18.03, or permission of instructor
U (Fall)
4-2-6 units

Application of the principles of energy and mass flow to major human organ systems. Anatomical, physiological and clinical features of the cardiovascular, respiratory and renal systems. Mechanisms of regulation and homeostasis. Systems, features and devices that are most illuminated by the methods of physical sciences and engineering models. Required laboratory work includes animal studies. Students taking graduate version complete additional assignments.
T. Heldt, R. G. Mark

6.4822[J] Quantitative Physiology: Organ Transport Systems
Same subject as 2.796[J]
Subject meets with 2.792[J], 6.4820[J], HST.542[J]
Prereq: 6.4810[J] and (2.006 or 6.2300)
G (Fall)
4-2-6 units

Application of the principles of energy and mass flow to major human organ systems. Anatomical, physiological and clinical features of the cardiovascular, respiratory and renal systems. Mechanisms of regulation and homeostasis. Systems, features and devices that are most illuminated by the methods of physical sciences and engineering models. Required laboratory work includes animal studies. Students taking graduate version complete additional assignments.
T. Heldt, R. G. Mark

6.4830[J] Fields, Forces and Flows in Biological Systems
Same subject as 2.793[J], 20.330[J]
Prereq: Biology (GIR), Physics II (GIR), and 18.03
U (Spring)
4-0-8 units

See description under subject 20.330[J].
J. Han, S. Manalis

6.4832[J] Fields, Forces, and Flows in Biological Systems
Same subject as 2.795[J], 10.539[J], 20.430[J]
Prereq: Permission of instructor
G (Fall)
3-0-9 units

See description under subject 20.430[J].
M. Bathe, A. J. Grodzinsky

6.4840[J] Molecular, Cellular, and Tissue Biomechanics
Same subject as 2.797[J], 3.053[J], 20.310[J]
Subject meets with 2.798[J], 3.971[J], 6.4842[J], 10.537[J], 20.410[J]
Prereq: Biology (GIR) and 18.03
U (Spring)
4-0-8 units

See description under subject 20.310[J].
M. Bathe, K. Ribbeck, P. T. So

6.4842[J] Molecular, Cellular, and Tissue Biomechanics
Same subject as 2.798[J], 3.971[J], 10.537[J], 20.410[J]
Subject meets with 2.797[J], 3.053[J], 6.4840[J], 20.310[J]
Prereq: Biology (GIR) and 18.03
G (Spring)
3-0-9 units

See description under subject 20.410[J].
M. Bathe, K. Ribbeck, P. T. So

6.4860[J] Medical Device Design
Same subject as 2.750[J]
Subject meets with 2.75[J], 6.4861[J], HST.552[J]
Prereq: 2.008, 6.2040, 6.2050, 6.2060, 22.071, or permission of instructor
U (Spring)
3-3-6 units

See description under subject 2.750[J]. Enrollment limited.
A. H. Slocum, E. Roche, N. C. Hanumara, G. Traverso, A. Pennes

6.4861[J] Medical Device Design
Same subject as 2.75[J], HST.552[J]
Subject meets with 2.750[J], 6.4860[J]
Prereq: 2.008, 6.2040, 6.2050, 6.2060, 22.071, or permission of instructor
G (Spring)
3-3-6 units

See description under subject 2.75[J]. Enrollment limited.
A. H. Slocum, E. Roche, N. C. Hanumara, G. Traverso, A. Pennes

6.4880[J] Biological Circuit Engineering Laboratory
Same subject as 20.129[J]
Prereq: Biology (GIR) and Calculus II (GIR)
U (Spring)
2-8-2 units. Institute LAB

See description under subject 20.129[J]. Enrollment limited.
T. Lu, R. Weiss

6.4900 Introduction to EECS via Medical Technology
Prereq: Calculus II (GIR) and Physics II (GIR)
U (Spring)
4-4-4 units. Institute LAB

Explores biomedical signals generated from electrocardiograms, glucose detectors or ultrasound images, and magnetic resonance images. Topics include physical characterization and modeling of systems in the time and frequency domains; analog and digital signals and noise; basic machine learning including decision trees, clustering, and classification; and introductory machine vision. Labs designed to strengthen background in signal processing and machine learning. Students design and run structured experiments, and develop and test procedures through further experimentation.
C. M. Stultz, E. Adalsteinsson

6.8800[J] Biomedical Signal and Image Processing
Same subject as 16.456[J], HST.582[J]
Subject meets with 6.8801[J], HST.482[J]
Prereq: (6.3700 and (2.004, 6.3000, 16.002, or 18.085)) or permission of instructor
Acad Year 2023-2024: G (Spring)
Acad Year 2024-2025: Not offered
3-1-8 units

Fundamentals of digital signal processing with emphasis on problems in biomedical research and clinical medicine. Basic principles and algorithms for processing both deterministic and random signals. Topics include data acquisition, imaging, filtering, coding, feature extraction, and modeling. Lab projects, performed in MATLAB, provide practical experience in processing physiological data, with examples from cardiology, speech processing, and medical imaging. Lectures cover signal processing topics relevant to the lab exercises, as well as background on the biological signals processed in the labs. Students taking graduate version complete additional assignments.
J. Greenberg, E. Adalsteinsson, W. Wells

6.8801[J] Biomedical Signal and Image Processing
Same subject as HST.482[J]
Subject meets with 6.8800[J], 16.456[J], HST.582[J]
Prereq: (6.3700 or permission of instructor) and (2.004, 6.3000, 16.002, or 18.085)
Acad Year 2023-2024: U (Spring)
Acad Year 2024-2025: Not offered
3-1-8 units

Fundamentals of digital signal processing with emphasis on problems in biomedical research and clinical medicine. Basic principles and algorithms for processing both deterministic and random signals. Topics include data acquisition, imaging, filtering, coding, feature extraction, and modeling. Lab projects, performed in MATLAB, provide practical experience in processing physiological data, with examples from cardiology, speech processing, and medical imaging. Lectures cover signal processing topics relevant to the lab exercises, as well as background on the biological signals processed in the labs. Students taking graduate version complete additional assignments.
J. Greenberg, E. Adalsteinsson, W. Wells

6.8810[J] Data Acquisition and Image Reconstruction in MRI
Same subject as HST.580[J]
Prereq: 6.3010
Acad Year 2023-2024: G (Fall)
Acad Year 2024-2025: Not offered
3-0-9 units

Applies analysis of signals and noise in linear systems, sampling, and Fourier properties to magnetic resonance (MR) imaging acquisition and reconstruction. Provides adequate foundation for MR physics to enable study of RF excitation design, efficient Fourier sampling, parallel encoding, reconstruction of non-uniformly sampled data, and the impact of hardware imperfections on reconstruction performance. Surveys active areas of MR research. Assignments include Matlab-based work with real data. Includes visit to a scan site for human MR studies.
E. Adalsteinsson

6.8830[J] Signal Processing by the Auditory System: Perception
Same subject as HST.716[J]
Prereq: (6.3000 and (6.3700 or 6.3702)) or permission of instructor
G (Fall)
Not offered regularly; consult department
3-0-9 units

Studies information processing performance of the human auditory system in relation to current physiological knowledge. Examines mathematical models for the quantification of auditory-based behavior and the relation between behavior and peripheral physiology, reflecting the tono-topic organization and stochastic responses of the auditory system. Mathematical models of psychophysical relations, incorporating quantitative knowledge of physiological transformations by the peripheral auditory system.
L. D. Braida

Vision

6.8300 Advances in Computer Vision
Subject meets with 6.8301
Prereq: (6.1200[J] or 6.3700) and (18.06 or 18.C06[J])
G (Spring)
3-0-9 units

Advanced topics in computer vision with a focus on the use of machine learning techniques and applications in graphics and human-computer interface. Covers image representations, texture models, structure-from-motion algorithms, Bayesian techniques, object and scene recognition, tracking, shape modeling, and image databases. Applications may include face recognition, multimodal interaction, interactive systems, cinematic special effects, and photorealistic rendering. Covers topics complementary to 6.8390. Students taking graduate version complete additional assignments.
W. T. Freeman, M. Konakovic Lukovic, V. Sitzmann

6.8301 Advances in Computer Vision
Subject meets with 6.8300
Prereq: (6.1200[J] or 6.3700) and (18.06 or 18.C06[J])
U (Spring)
4-0-11 units

Advanced topics in computer vision with a focus on the use of machine learning techniques and applications in graphics and human-computer interface. Covers image representations, texture models, structure-from-motion algorithms, Bayesian techniques, object and scene recognition, tracking, shape modeling, and image databases. Applications may include face recognition, multimodal interaction, interactive systems, cinematic special effects, and photorealistic rendering. Includes instruction and practice in written and oral communication. Students taking graduate version complete additional assignments.
W. T. Freeman, M. Konakovic Lukovic, V. Sitzmann

6.8320 Advanced Topics in Computer Vision
Prereq: 6.801, 6.8300, or permission of instructor
G (Fall)
Not offered regularly; consult department
3-0-9 units
Can be repeated for credit.

Seminar exploring advanced research topics in the field of computer vision; focus varies with lecturer. Typically structured around discussion of assigned research papers and presentations by students. Example research areas explored in this seminar include learning in vision, computational imaging techniques, multimodal human-computer interaction, biomedical imaging, representation and estimation methods used in modern computer vision.
W. T. Freeman, B. K. P. Horn, A. Torralba

6.8370 Advanced Computational Photography
Subject meets with 6.8371
Prereq: Calculus II (GIR) and 6.1020
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Fall)
3-0-9 units

Presents fundamentals and applications of hardware and software techniques used in digital and computational photography, with an emphasis on software methods. Provides sufficient background to implement solutions to photographic challenges and opportunities. Topics include cameras and image formation, image processing and image representations, high-dynamic-range imaging, human visual perception and color, single view 3-D model reconstruction, morphing, data-rich photography, super-resolution, and image-based rendering. Students taking graduate version complete additional assignments.
F. P. Durand

6.8371 Digital and Computational Photography
Subject meets with 6.8370
Prereq: Calculus II (GIR) and 6.1010
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: U (Fall)
3-0-9 units

Presents fundamentals and applications of hardware and software techniques used in digital and computational photography, with an emphasis on software methods. Provides sufficient background to implement solutions to photographic challenges and opportunities. Topics include cameras and image formation, image processing and image representations, high-dynamic-range imaging, human visual perception and color, single view 3-D model reconstruction, morphing, data-rich photography, super-resolution, and image-based rendering. Students taking graduate version complete additional assignments.
F. P. Durand

Natural Language Processing & Speech

6.8610 Quantitative Methods for Natural Language Processing
Subject meets with 6.8611
Prereq: 6.3900 and (18.06 or 18.C06[J])
G (Fall)
3-0-9 units

Introduces the study of human language from a computational perspective, including syntactic, semantic and discourse processing models. Emphasizes machine learning methods and algorithms. Uses these methods and models in applications such as syntactic parsing, information extraction, statistical machine translation, dialogue systems. Students taking graduate version complete additional assignments.
J. Andreas, J. Glass

6.8611 Quantitative Methods for Natural Language Processing
Subject meets with 6.8610
Prereq: 6.3900 and (18.06 or 18.C06[J])
U (Fall)
4-0-11 units

Introduces the study of human language from a computational perspective, including syntactic, semantic and discourse processing models. Emphasizes machine learning methods and algorithms. Uses these methods and models in applications such as syntactic parsing, information extraction, statistical machine translation, dialogue systems. Instruction and practice in oral and written communication provided. Students taking graduate version complete additional assignments.
J. Andreas, J. Glass

6.8620[J] Spoken Language Processing
Same subject as HST.728[J]
Prereq: 6.3000 and 6.3900
Acad Year 2023-2024: G (Spring)
Acad Year 2024-2025: Not offered
3-1-8 units

Introduces the rapidly developing field of spoken language processing including automatic speech recognition. Topics include acoustic theory of speech production, acoustic-phonetics, signal representation, acoustic and language modeling, search, hidden Markov modeling, neural networks models, end-to-end deep learning models, and other machine learning techniques applied to speech and language processing topics. Lecture material intersperses theory with practice. Includes problem sets, laboratory exercises, and open-ended term project.
J. R. Glass

6.8630[J] Natural Language and the Computer Representation of Knowledge
Same subject as 9.611[J], 24.984[J]
Prereq: 6.4100
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Spring)
3-3-6 units

Explores the relationship between the computer representation and acquisition of knowledge and the structure of human language, its acquisition, and hypotheses about its differentiating uniqueness. Emphasizes development of analytical skills necessary to judge the computational implications of grammatical formalisms and their role in connecting human intelligence to computational intelligence. Uses concrete examples to illustrate particular computational issues in this area.
R. C. Berwick

Cross-cutting EECS Subjects

6.9000 Engineering for Impact
Prereq: 6.1910, 6.2000, and 6.3100
U (Spring)
2-3-7 units

Students work in large teams to engineer hardware/software systems that solve important problems in society. Topics include requirements, specifications, system design and partitioning, detailed engineering design, prototyping and implementation, test and verification, and the ethical implications of these choices. Explores case studies of existing hardware/software systems to understand implications of different system design choices. Teams design and build functional prototypes of useful systems. Grading is based on individual- and team-based elements. Enrollment may be limited due to staffing and space requirements.
J. Voldman

6.9010 Introduction to EECS via Interconnected Embedded Systems
Prereq: 6.100A; *Coreq: Physics II (GIR)*
U (Spring)
Not offered regularly; consult department
1-5-6 units. Institute LAB

Introduction to embedded systems in the context of connected devices, wearables, and the "Internet of Things" (IoT). Topics include microcontrollers, energy utilization, algorithmic efficiency, interfacing with sensors, networking, cryptography, and local versus distributed computation. Students design, make, and program an Internet-connected wearable or handheld device. In the final project, student teams design and demo their own server-connected IoT system. Enrollment limited; preference to first- and second-year students.
S. Mueller, J. D. Steinmeyer, J. Voldman

6.9020[J] How to Make (Almost) Anything
Same subject as 4.140[J], MAS.863[J]
Prereq: Permission of instructor
G (Fall)
3-9-6 units

See description under subject MAS.863[J].
N. Gershenfeld, J. DiFrancesco, J. Lavallee, G. Darcey

6.9030 Strobe Project Laboratory
Prereq: Physics II (GIR) or permission of instructor
U (Fall, Spring)
2-8-2 units. Institute LAB

Application of electronic flash sources to measurement and photography. First half covers fundamentals of photography and electronic flashes, including experiments on application of electronic flash to photography, stroboscopy, motion analysis, and high-speed videography. Students write four extensive lab reports. In the second half, students work in small groups to select, design, and execute independent projects in measurement or photography that apply learned techniques. Project planning and execution skills are discussed and developed over the term. Students engage in extensive written and oral communication exercises. Enrollment limited.
J. K. Vandiver, J. W. Bales

6.9080 Introduction to EECS via Robotics
Prereq: 6.100A or permission of instructor
U (Spring)
Not offered regularly; consult department
2-4-6 units. Institute LAB

An integrated introduction to electrical engineering and computer science, taught using substantial laboratory experiments with mobile robots. Key issues in the design of engineered artifacts operating in the natural world: measuring and modeling system behaviors; assessing errors in sensors and effectors; specifying tasks; designing solutions based on analytical and computational models; planning, executing, and evaluating experimental tests of performance; refining models and designs. Issues addressed in the context of computer programs, control systems, probabilistic inference problems, circuits and transducers, which all play important roles in achieving robust operation of a large variety of engineered systems.
D. M. Freeman, A. Hartz, L. P. Kaelbling, T. Lozano-Perez

6.UAR Seminar in Undergraduate Advanced Research
Prereq: Permission of instructor
U (Fall, Spring)
2-0-4 units
Can be repeated for credit.

Instruction in effective undergraduate research, including choosing and developing a research topic, surveying previous work and publications, research topics in EECS and the School of Engineering, industry best practices, design for robustness, technical presentation, authorship and collaboration, and ethics. Students engage in extensive written and oral communication exercises, in the context of an approved advanced research project. A total of 12 units of credit is awarded for completion of the fall and subsequent spring term offerings. Application required; consult EECS SuperUROP website for more information.
D. Katabi, A. P. Chandrakasan

6.UAT Oral Communication
Prereq: None
U (Fall)
3-0-6 units

Provides instruction in aspects of effective technical oral presentations and exposure to communication skills useful in a workplace setting. Students create, give and revise a number of presentations of varying length targeting a range of different audiences. Enrollment may be limited.
T. L. Eng

Gordon Engineering Leadership Program

6.9101[J] Introduction to Design Thinking and Innovation in Engineering
Same subject as 2.7231[J], 16.6621[J]
Prereq: None
U (Fall, Spring; first half of term)
2-0-1 units

Introduces students to concepts of design thinking and innovation that can be applied to any engineering discipline. Focuses on introducing an iterative design process, a systems-thinking approach for stakeholder analysis, methods for articulating design concepts, methods for concept selection, and techniques for testing with users. Provides an opportunity for first-year students to explore product or system design and development, and to build their understanding of what it means to lead and coordinate projects in engineering design. Subject can count toward the 6-unit discovery-focused credit limit for first-year students. Enrollment limited to 25; priority to first-year students.
B. Kotelly

6.910A Design Thinking and Innovation Leadership for Engineers
Engineering School-Wide Elective Subject.
Offered under: 2.723A, 6.910A, 16.662A
Prereq: None
U (Fall, Spring; first half of term)
2-0-1 units

Introductory subject in design thinking and innovation. Develops students' ability to conceive, implement, and evaluate successful projects in any engineering discipline. Lessons focus on an iterative design process, a systems-thinking approach for stakeholder analysis, methods for articulating design concepts, methods for concept selection, and techniques for testing with users.
B. Kotelly

6.910B Design Thinking and Innovation Project
Engineering School-Wide Elective Subject.
Offered under: 2.723B, 6.910B, 16.662B
Prereq: 6.910A
U (Fall, Spring; second half of term)
2-0-1 units

Project-based subject. Students employ design-thinking techniques learned in 6.902A to develop a robust speech-recognition application using a web-based platform. Students practice in leadership and teamwork skills as they collaboratively conceive, implement, and iteratively refine their designs based on user feedback. Topics covered include techniques for leading the creative process in teams, the ethics of engineering systems, methods for articulating designs with group collaboration, identifying and reconciling paradoxes of engineering designs, and communicating solution concepts with impact. Students present oral presentations and receive feedback to sharpen their communication skills.
B. Kotelly

6.9110 Engineering Leadership Lab
Engineering School-Wide Elective Subject.
Offered under: 6.9110, 16.650
Subject meets with 6.9130[J], 16.667[J]
Prereq: None. *Coreq: 6.9120*; or permission of instructor
U (Fall, Spring)
0-2-1 units
Can be repeated for credit.

See description under subject 6.9130. Preference to students enrolled in the Bernard M. Gordon-MIT Engineering Leadership Program.
L. McGonagle, J. Feiler

6.9120 Engineering Leadership
Engineering School-Wide Elective Subject.
Offered under: 6.9120, 16.651
Prereq: None. *Coreq: 6.9110*; or permission of instructor
U (Fall, Spring)
1-0-2 units
Can be repeated for credit.

Exposes students to the models and methods of engineering leadership within the contexts of conceiving, designing, implementing and operating products, processes and systems. Introduces the Capabilities of Effective Engineering Leaders, and models and theories related to the capabilities. Discusses the appropriate times and reasons to use particular models to deliver engineering success. Includes occasional guest speakers or panel discussions. May be repeated for credit once with permission of instructor. Preference to first-year students in the Gordon Engineering Leadership Program.
J. Magarian

6.9130 Engineering Leadership Lab
Engineering School-Wide Elective Subject.
Offered under: 6.9130, 16.667
Subject meets with 6.9110[J], 16.650[J]
Prereq: 6.910A, 6.9110, 6.9120, or permission of instructor
U (Fall, Spring)
0-2-4 units
Can be repeated for credit.

Advances students' leadership, teamwork and communication skills through further exposure to leadership frameworks, models, and cases within an engineering context in an interactive, practice-based environment. Students coach others, assess performance, and lead guided reflections on individual and team successes, while discovering opportunities for improvement. Students assist with programmatic planning and implementation of role-play simulations, small group discussions, and performance and peer assessments by and of other students and by instructors. Includes frequent engineering industry-guest participation and involvement. Content is frequently student-led. Second year Gordon Engineering Leadership Program (GEL) Program students register for 6.913. Preference to students enrolled in the second year of the Gordon-MIT Engineering Leadership Program.
L. McGonagle, J. Feiler

6.9140 Project Engineering
Engineering School-Wide Elective Subject.
Offered under: 6.9140, 16.669
Prereq: (6.910A and (6.9110 or 6.9120)) or permission of instructor
U (IAP)
4-0-0 units

Students attend and participate in a four-day off-site workshop covering an introduction to basic principles, methods, and tools for project management in a realistic context. In teams, students create a plan for a project of their choice in one of several areas, including: aircraft modification, factory automation, flood prevention engineering, solar farm engineering, small-business digital transformation/modernization, and disaster response, among others. Develops skills applicable to the planning and management of complex engineering projects. Topics include cost-benefit analysis, resource and cost estimation, and project control and delivery which are practiced during an experiential, team-based activity. Case studies highlight projects in both hardware/software and consumer packaged goods. Preference to students in the Bernard M. Gordon-MIT Engineering Leadership Program.
O. de Weck, J. Feiler, L. McGonagle, R. Rahaman

6.9150[J] Leading Innovation in Teams
Same subject as 16.671[J]
Prereq: None
U (Spring)
Not offered regularly; consult department
3-0-6 units

Empowers future innovators in engineering and technology with a foundation of leadership and teamwork skills. Grounded in research but practical in focus, equips students with leadership competencies such as building self-awareness, motivating and developing others, influencing without authority, managing conflict, and communicating effectively. Teamwork skills include how to convene, launch, and develop various types of teams, including project teams. Reviews recent advances in implementing innovations and building personal capacity for lifelong learning as a leading innovator. Enrollment limited to seating capacity of classroom. Admittance may be controlled by lottery.
D. Nino, J. Schindall

6.9160[J] Engineering Innovation: Global Security Systems
Same subject as 15.359[J]
Prereq: None
U (Spring)
3-3-6 units

See description under subject 15.359[J].
F. Murray, V. Bulovic, G. Keselman

6.9260 Multistakeholder Negotiation for Technical Experts
Prereq: None
G (Spring)
2-0-4 units

Presents strategies and proven techniques for improving communications, relationships, and decision-making in groups using simulations, role-plays, case studies, and video analysis. Aims to provide the skill set needed to effectively negotiate with both internal and external stakeholders to align efforts and overcome differences. No prior experience in negotiation required. Satisfies the requirements for the Graduate Certificate in Technical Leadership.
S. Dinnar

6.9270 Negotiation and Influence Skills for Technical Leaders
Prereq: None
G (Fall)
2-0-4 units

Focuses around the premise that the abilities to negotiate with, and influence others, are essential to being an effective leader in technology rich environments. Provides graduate students with underlying principles and a repertoire of negotiation and influence skills that apply to interpersonal situations, particularly those where an engineer or project leader lacks formal authority over others in delivering results. Utilizes research-based approaches through the application of multiple learning methods, including experiential role plays, case studies, assessments, feedback, and personal reflections. Concepts such as the zone of possible agreements, best alternative to negotiated agreements, and sources of influence are put into practice. Satisfies the requirements for the Graduate Certificate in Technical Leadership.
D. Nino, J. Wu

6.9280[J] Leading Creative Teams
Same subject as 15.674[J], 16.990[J]
Prereq: Permission of instructor
G (Fall, Spring)
3-0-6 units

Prepares students to lead teams charged with developing creative solutions in engineering and technical environments. Grounded in research but practical in focus, equips students with leadership competencies such as building self-awareness, motivating and developing others, creative problem solving, influencing without authority, managing conflict, and communicating effectively. Teamwork skills include how to convene, launch, and develop various types of teams, including project teams. Learning methods emphasize personalized and experiential skill development. Enrollment limited.
D. Nino, J. Wu

6.EPE UPOP Engineering Practice Experience
Engineering School-Wide Elective Subject.
Offered under: 1.EPE, 2.EPE, 3.EPE, 6.EPE, 8.EPE, 10.EPE, 15.EPE, 16.EPE, 20.EPE, 22.EPE
Prereq: None
U (Fall, Spring)
0-0-1 units
Can be repeated for credit.

See description under subject 2.EPE. Application required; consult UPOP website for more information.
K. Tan-Tiongco, D. Fordell

6.EPW UPOP Engineering Practice Workshop
Engineering School-Wide Elective Subject.
Offered under: 1.EPW, 2.EPW, 3.EPW, 6.EPW, 10.EPW, 16.EPW, 20.EPW, 22.EPW
Prereq: 2.EPE
U (IAP, Spring)
1-0-0 units

See description under subject 2.EPW. Enrollment limited to those in the UPOP program.
K. Tan-Tiongco, D. Fordell

EECS & Beyond

6.9300 StartMIT: Workshop for Entrepreneurs and Innovators
Subject meets with 6.9302[J], 15.352[J]
Prereq: None
U (IAP)
4-0-2 units

Designed for students who are interested in entrepreneurship and want to explore the potential commercialization of their research project. Introduces practices for building a successful company, such as idea creation and validation, defining a value proposition, building a team, marketing, customer traction, and possible funding models. Students taking graduate version complete different assignments.
A. Chandrakasan, C. Chase, B. Aulet

6.9302[J] StartMIT: Workshop for Entrepreneurs and Innovators
Same subject as 15.352[J]
Subject meets with 6.9300
Prereq: None
G (IAP)
4-0-2 units

Designed for students who are interested in entrepreneurship and want to explore the potential commercialization of their research project. Introduces practices for building a successful company, such as idea creation and validation, defining a value proposition, building a team, marketing, customer traction, and possible funding models. Students taking graduate version complete different assignments.
B. Aulet, A. Chandrakasan, C. Chase

6.9310 Patents, Copyrights, and the Law of Intellectual Property
Prereq: None
U (Fall)
Not offered regularly; consult department
2-0-4 units

Intensive introduction to the law, focusing on intellectual property, patents, copyrights, trademarks, and trade secrets. Covers the process of drafting and filing patent applications, enforcement of patents in the courts, the differences between US and international IP laws and enforcement mechanisms, and the inventor's ability to monetize and protect his/her innovations. Highlights current legal issues and trends relating to the technology, and life sciences industries. Readings include judicial opinions and statutory material. Class projects include patent drafting, patent searching, and patentability opinions, and courtroom presentation.
S. M. Bauer

6.9320 Ethics for Engineers
Engineering School-Wide Elective Subject.
Offered under: 1.082, 2.900, 6.9320, 10.01, 16.676, 22.014
Subject meets with 6.9321, 20.005
Prereq: None
U (Fall, Spring)
2-0-4 units

See description under subject 10.01.
D. A. Lauffenberger, B. L. Trout

6.9321 Ethics for Engineers - Independent Inquiry
Subject meets with 1.082[J], 2.900[J], 6.9320[J], 10.01[J], 16.676[J], 20.005, 22.014[J]
Prereq: None
U (Fall)
Not offered regularly; consult department
2-0-10 units

Explores the ethical principles by which an engineer ought to be guided. Integrates foundational texts in ethics with case studies illustrating ethical problems arising in the practice of engineering. Readings from classic sources including Aristotle, Kant, Machiavelli, Hobbes, Locke, Rousseau, Franklin, Tocqueville, Arendt, and King. Case studies include articles and films that address engineering disasters, safety, biotechnology, the internet and AI, and the ultimate scope and aims of engineering. Different sections may focus on themes, such as AI or biotechnology. To satisfy the independent inquiry component of this subject, students expand the scope of their term project. Students taking 20.005 focus their term project on a problem in biological engineering in which there are intertwined ethical and technical issues.
D. A. Lauffenburger, B. L. Trout

6.9350[J] Financial Market Dynamics and Human Behavior
Same subject as 15.481[J]
Prereq: 15.401, 15.414, or 15.415
Acad Year 2023-2024: Not offered
Acad Year 2024-2025: G (Spring)
4-0-5 units

See description under subject 15.481[J]. Enrollment may be limited; preference to Sloan graduate students.
A. Lo

6.9360 Management in Engineering
Engineering School-Wide Elective Subject.
Offered under: 2.96, 6.9360, 10.806, 16.653
Prereq: None
U (Fall)
3-1-8 units

See description under subject 2.96. Restricted to juniors and seniors.
H. S. Marcus, J.-H. Chun

Independent Activities Period

6.9500 Introduction to MATLAB
Prereq: None
U (IAP)
Not offered regularly; consult department
1-0-2 units

Accelerated introduction to MATLAB and its popular toolboxes. Lectures are interactive, with students conducting sample MATLAB problems in real time. Includes problem-based MATLAB assignments. Students must provide their own laptop and software. Enrollment limited.
Staff

6.9510 Introduction to Signals and Systems, and Feedback Control
Prereq: Calculus II (GIR) or permission of instructor
U (IAP)
Not offered regularly; consult department
2-2-2 units

Introduces fundamental concepts for 6.003, including Fourier and Laplace transforms, convolution, sampling, filters, feedback control, stability, and Bode plots. Students engage in problem solving, using Mathematica and MATLAB software extensively to help visualize processing in the time frequency domains.
Staff

6.9520 Introduction to Electrical Engineering Lab Skills
Prereq: None
U (IAP)
Not offered regularly; consult department
1-3-2 units

Introduces basic electrical engineering concepts, components, and laboratory techniques. Covers analog integrated circuits, power supplies, and digital circuits. Lab exercises provide practical experience in constructing projects using multi-meters, oscilloscopes, logic analyzers, and other tools. Includes a project in which students build a circuit to display their own EKG. Enrollment limited.
G. P. Hom

6.9550 Structure and Interpretation of Computer Programs
Prereq: None
U (IAP)
Not offered regularly; consult department
1-0-5 units

Studies the structure and interpretation of computer programs which transcend specific programming languages. Demonstrates thought patterns for computer science using Scheme. Includes weekly programming projects. Enrollment may be limited.
Staff

6.9560 Introduction to Software Engineering in Java
Prereq: None
U (IAP)
Not offered regularly; consult department
1-1-4 units

Covers the fundamentals of Java, helping students develop intuition about object-oriented programming. Focuses on developing working software that solves real problems. Designed for students with little or no programming experience. Concepts covered useful to 6.3100. Enrollment limited.
Staff

6.9570 Introduction to C and C++
Prereq: None
U (IAP)
Not offered regularly; consult department
3-3-0 units

Fast-paced introduction to the C and C++ programming languages. Intended for those with experience in other languages who have never used C or C++. Students complete daily assignments, a small-scale individual project, and a mandatory online diagnostic test. Enrollment limited.
Staff

6.9600 Mobile Autonomous Systems Laboratory: MASLAB
Prereq: None
U (IAP)
2-2-2 units
Can be repeated for credit.

Autonomous robotics contest emphasizing technical AI, vision, mapping and navigation from a robot-mounted camera. Few restrictions are placed on materials, sensors, and/or actuators enabling teams to build robots very creatively. Teams should have members with varying engineering, programming and mechanical backgrounds. Culminates with a robot competition at the end of IAP. Enrollment limited.
Staff

6.9610 The Battlecode Programming Competition
Prereq: None
U (IAP)
2-0-4 units
Can be repeated for credit.

Artificial Intelligence programming contest in Java. Student teams program virtual robots to play Battlecode, a real-time strategy game. Competition culminates in a live BattleCode tournament. Assumes basic knowledge of programming.
Staff

6.9620 Web Lab: A Web Programming Class and Competition
Prereq: None
U (IAP)
1-0-5 units
Can be repeated for credit.

Student teams learn to build a functional and user-friendly website. Topics include version control, HTML, CSS, JavaScript, ReactJS, and nodejs. All teams are eligible to enter a competition where sites are judged by industry experts. Beginners and experienced web programmers welcome, but some previous programming experience is recommended. Registration on subject website required.
Staff

6.9630 Pokerbots Competition
Prereq: None
U (IAP)
1-0-5 units
Can be repeated for credit.

Build autonomous poker players and aquire the knowledge of the game of poker. Showcase decision making skills, apply concepts in mathematics, computer science and economics. Provides instruction in programming, game theory, probability and statistics and machine learning. Concludes with a final competition and prizes. Enrollment limited.
Staff

Non-classroom & Career

6.9700 Studies in Artificial Intelligence and Decision Making
Prereq: Permission of department
G (Fall)
Not offered regularly; consult department
0-0-48 units

Introduction to artificial intelligence and decision making in a series of online subjects followed by a comprehensive examination. Probability: distributions and probabilistic calculations, inference methods, laws of large numbers, and random processes. Statistical data analysis: linear regression, parameter estimation, hypothesis testing, model selection, and causal inference. Machine learning: linear classification, fundamentals of supervised machine learning, deep learning, unsupervised learning, and generative models. Online decision making: online optimization, online learning, Markov decision processes and reinforcement learning, elements of control theory, and fundamentals of game theory. Computer vision: fundamentals of image and signal processing, introduction to machine learning for vision, generative models and representation learning, and elements of scene understanding. Restricted to Artificial Intelligence and Decision Making MicroMasters Credential holders in the AI+D Blended Master's program.
A. Madry, P. Parrilo

6.9710 Internship in Artificial Intelligence and Decision Making
Prereq: Permission of department
G (Spring, Summer)
Units arranged [P/D/F]

Provides an opportunity for students to synthesize their coursework and to apply the knowledge gained in the program towards a project with a host organization. All internship placements are subject to approval by program director. Each student must write a capstone project report. Restricted to students in the AI+D blended master's program.
A. Madry, P. Parrilo

6.9720 Research in Artificial Intelligence and Decision Making
Prereq: Permission of department
G (Spring, Summer)
0-0-12 units

Individual research project arranged with appropriate faculty member or approved supervisor. A final paper summarizing research is required. Restricted to students in the AI+D blended master¿s program.
A. Madry, P. Parrilo

6.9800 Independent Study in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall, IAP, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit.

Opportunity for independent study at the undergraduate level under regular supervision by a faculty member. Study plans require prior approval.
Consult Department Undergraduate Office

6.9820 Practical Internship Experience
Prereq: None
U (Fall, IAP, Spring, Summer)
0-1-0 units
Can be repeated for credit.

For Course 6 students participating in curriculum-related off-campus internship experiences in electrical engineering or computer science. Before enrolling, students must have an employment offer from a company or organization and must find an EECS supervisor. Upon completion of the internship the student must submit a letter from the employer evaluating the work accomplished, a substantive final report from the student, approved by the MIT supervisor. Subject to departmental approval. Consult Department Undergraduate Office for details on procedures and restrictions.
Consult Department Undergraduate Office

6.9830 Professional Perspective Internship
Prereq: None
G (Fall, IAP, Spring, Summer)
0-1-0 units

Required for Course 6 MEng students to gain professional experience in electrical engineering or computer science through an internship (industry, government, or academic) of 4 or more weeks in IAP or summer. This can be completed as MEng students or as undergrads, through previous employment completed while deferring MEng entry or by attending a series of three colloquia, seminars, or technical talks related to their field. For internships/work experience, a letter from the employer confirming dates of employment is required. All students are required to write responses to short essay prompts about their professional experience. International students must consult ISO and the EECS Undergraduate Office on work authorization and allowable employment dates.
Consult Department Undergraduate Office

6.9840 Practical Experience in EECS
Prereq: None
G (Fall, IAP, Spring, Summer)
0-1-0 units
Can be repeated for credit.

For Course 6 students in the MEng program who seek practical off-campus research experiences or internships in electrical engineering or computer science. Before enrolling, students must have an offer of employment from a company or organization and secure a supervisor within EECS. Employers must document the work accomplished. Proposals subject to departmental approval. For students who begin the MEng program in the summer only, the experience or internship cannot exceed 20 hours per week and must begin no earlier than the first day of the Summer Session, but may end as late as the last business day before the Fall Term.
Consult Department Undergraduate Office

6.9850 6-A Internship
Prereq: None
U (Fall, Spring, Summer)
0-12-0 units

Provides academic credit for the first assignment of 6-A undergraduate students at companies affiliated with the department's 6-A internship program. Limited to students participating in the 6-A internship program.
T. Palacios

6.9860 Advanced 6-A Internship
Prereq: 6.9850
U (Fall, Spring, Summer)
0-12-0 units

Provides academic credit for the second assignment of 6-A undergraduate students at companies affiliated with the department's 6-A internship program. Limited to students participating in the 6-A internship program.
T. Palacios

6.9870 Graduate 6-A Internship
Prereq: 6.9850 or 6.9860
G (Fall, Spring, Summer)
0-12-0 units

Provides academic credit for a graduate assignment of graduate 6-A students at companies affiliated with the department's 6-A internship program. Limited to graduate students participating in the 6-A internship program.
T. Palacios

6.9880 Graduate 6-A Internship
Prereq: 6.9870
G (Fall, Spring, Summer)
0-12-0 units

Provides academic credit for graduate students in the second half of their 6-A MEng industry internship. Limited to graduate students participating in the 6-A internship program.
T. Palacios

6.9900 Teaching Electrical Engineering and Computer Science
Prereq: None
G (Fall, Spring)
Units arranged [P/D/F]
Can be repeated for credit.

For Teaching Assistants in Electrical Engineering and Computer Science, in cases where teaching assignment is approved for academic credit by the department.
E. Adalsteinsson, D. M. Freeman, L. P. Kaelbling, R. C. Miller

6.9910 Research in Electrical Engineering and Computer Science
Prereq: None
G (Fall, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit.

For EECS MEng students who are Research Assistants in Electrical Engineering and Computer Science, in cases where the assigned research is approved for academic credit by the department. Hours arranged with research supervisor.
Consult Department Undergraduate Office

6.9920 Introductory Research in Electrical Engineering and Computer Science
Prereq: Permission of instructor
G (Fall, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit.

Enrollment restricted to first-year graduate students in Electrical Engineering and Computer Science who are doing introductory research leading to an SM, EE, ECS, PhD, or ScD thesis. Opportunity to become involved in graduate research, under guidance of a staff member, on a problem of mutual interest to student and supervisor. Individual programs subject to approval of professor in charge.
L. A. Kolodziejski

6.9930 Networking Seminars in EECS
Prereq: None
G (Fall)
Units arranged [P/D/F]

For first year Course 6 students in the SM/PhD track, who seek weekly engagement with departmental faculty and staff, to discuss topics related to the graduate student experience, and to promote a successful start to graduate school.
J. Fischer

6.9932 Introduction to Research in Electrical Engineering and Computer Science
Prereq: Permission of instructor
G (Fall, Spring, Summer)
3-0-0 units

Seminar on topics related to research leading to an SM, EE, ECS, PhD, or ScD thesis. Limited to first-year regular graduate students in EECS with a fellowship or teaching assistantship.
L. A. Kolodziejski

6.9940 Professional Perspective I
Prereq: None
G (Fall, IAP, Spring, Summer)
0-0-1 units
Can be repeated for credit.

Required for Course 6 students in the doctoral program to gain professional perspective in research experiences, academic experiences, and internships in electrical engineering and computer science. Professional perspective options include: internships (with industry, government or academia), industrial colloquia or seminars, research collaboration with industry or government, and professional development for entry into academia or entrepreneurial engagement. For an internship experience, an offer of employment from a company or organization is required prior to enrollment; employers must document work accomplished. A written report is required upon completion of a minimum of 4 weeks of off-campus experiences. Proposals subject to departmental approval.
Consult Department Graduate Office

6.9950 Professional Perspective II
Prereq: 6.9940
G (Fall, IAP, Spring, Summer)
0-0-1 units
Can be repeated for credit.

Required for Course 6 students in the doctoral program to gain professional perspective in research experiences, academic experiences, and internships in electrical engineering and computer science. Professional perspective options include: internships (with industry, government or academia), industrial colloquia or seminars, research collaboration with industry or government, and professional development for entry into academia or entrepreneurial engagement. For an internship experience, an offer of employment from a company or organization is required prior to enrollment; employers must document work accomplished. A written report is required upon completion of a minimum of 4 weeks of off-campus experiences. Proposals subject to departmental approval.
Consult Department Graduate Office

6.9960 Experience in Technical Communication (New)
Prereq: Permission of instructor
G (Fall, Spring)
Units arranged [P/D/F]
Can be repeated for credit.

Provides training and practice in technical communication. Includes communication coaching, workshop facilitation, and other communication-related projects under supervision of Communication Lab staff. Students selected by interview. Enrollment limited by availability of suitable assignments. Enrollment could be limited if there isn't enough student participation.
D. Chien, D. Montgomery

6.9970 Academic Job Search
Prereq: Permission of instructor
G (Fall)
2-0-4 units

Interactive workshops and homework assignments provide guidance for the faculty application process, including CV; cover letter; research, teaching, and diversity statements; interview and job talk preparation; and post-offer negotiations. Includes perspectives of junior faculty, search committee members, and department leadership at MIT and other institutions. Academic Career Day provides opportunity for students to participate in one-on-one pre-interviews with external faculty. Preference to EECS senior PhD students and postdocs.
S. Amarasinghe, D. Montgomery

6.9990 Independent Study in Electrical Engineering and Computer Science
Prereq: None
G (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.

Opportunity for independent study under regular supervision by a faculty member. Projects require prior approval.
L. A. Kolodziejski

6.THG Graduate Thesis
Prereq: Permission of instructor
G (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.

Program of research leading to the writing of an SM, EE, ECS, PhD, or ScD thesis; to be arranged by the student and an appropriate MIT faculty member.
L. A. Kolodziejski

6.THM Master of Engineering Program Thesis
Prereq: None
G (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.

Program of research leading to the writing of an MEng thesis; to be arranged by the student and an appropriate MIT faculty member. Restricted to MEng graduate students.
Consult Department Undergraduate Office

6.UR Undergraduate Research in Electrical Engineering and Computer Science
Prereq: None
U (Fall, IAP, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit.

Individual research project arranged with appropriate faculty member or approved supervisor. Forms and instructions for the final report are available in the EECS Undergraduate Office.
Consult Department Undergraduate Office

Special Subjects

6.S040 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Fall)
Not offered regularly; consult department
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S041 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Fall, Spring)
Not offered regularly; consult department
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S042 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Fall, Spring)
Not offered regularly; consult department
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S043 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Fall)
Not offered regularly; consult department
3-0-9 units

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S044 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Fall, Spring)
Not offered regularly; consult department
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S045 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Fall)
Not offered regularly; consult department
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S046 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Fall)
Not offered regularly; consult department
3-0-9 units

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S047 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Fall)
Not offered regularly; consult department
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S050 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Spring)
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S051 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Spring)
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S052 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Spring)
3-0-3 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S053 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Spring)
Not offered regularly; consult department
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S054 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Spring)
Not offered regularly; consult department
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S055 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Spring)
Not offered regularly; consult department
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S056 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Spring)
Not offered regularly; consult department
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S057 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S058 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S059 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Fall)
Not offered regularly; consult department
Units arranged

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S060 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Fall)
Units arranged
Can be repeated for credit.

Basic undergraduate subjects not offered in the regular curriculum.
Consult Department

6.S061 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Fall, Spring)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Basic undergraduate subjects not offered in the regular curriculum.
Consult Department

6.S062 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Fall)
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S063 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Spring)
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S076 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Spring)
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S077 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall, Spring)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S078 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S079 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Spring)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S080 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S081 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S082 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S083 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S084 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S085 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S086 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S087 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S088 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S089 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S090 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Summer)
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
D. M. Freeman

6.S091 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S092 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S093 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
D. M. Freeman

6.S094 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S095 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S096 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S097 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S098 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S099 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S183 Special Laboratory Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Laboratory subject that covers content not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S184 Special Laboratory Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Laboratory subject that covers content not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S185 Special Laboratory Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Laboratory subject that covers content not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
D. M. Freeman

6.S186 Special Laboratory Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Laboratory subject that covers content not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S187 Special Laboratory Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Units arranged [P/D/F]
Can be repeated for credit.

Laboratory subject that covers content not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Staff

6.S188 Special Laboratory Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Laboratory subject that covers content not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
D. M. Freeman

6.S189 Special Laboratory Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Laboratory subject that covers content not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
D. M. Freeman

6.S190 Special Laboratory Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Units arranged [P/D/F]
Can be repeated for credit.

Laboratory subject that covers content not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
D. M. Freeman

6.S191 Special Laboratory Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Laboratory subject that covers content not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S192 Special Laboratory Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Laboratory subject that covers content not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S193 Special Laboratory Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Laboratory subject that covers content not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S197 Special Laboratory Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Units arranged
Can be repeated for credit.

Laboratory subject that covers content not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S193-6.S198 Special Laboratory Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Laboratory subject that covers content not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S630 Special Subject in Engineering Leadership (New)
Prereq: None
G (Spring)
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult the Gordon Engineering Leadership Program or Riccio Graduate Engineering Leadership Program to learn of offerings for a particular term.
Staff

6.S640 Special Subject in Engineering Leadership (New)
Prereq: None
G (Spring)
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult the Gordon Engineering Leadership Program or Riccio Graduate Engineering Leadership Program to learn of offerings for a particular term.
Staff

6.S650 Special Subject in Engineering Leadership (New)
Prereq: None
G (Spring)
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult the Gordon Engineering Leadership Program or Riccio Graduate Engineering Leadership Program to learn of offerings for a particular term.
Staff

6.S660 Special Subject in Engineering Leadership (New)
Prereq: None
G (Spring)
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult the Gordon Engineering Leadership Program or Riccio Graduate Engineering Leadership Program to learn of offerings for a particular term.
Staff

6.S890 Special Subject in Electrical Engineering and Computer Science (New)
Prereq: None
G (Fall)
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S891 Special Subject in Electrical Engineering and Computer Science (New)
Prereq: None
G (Fall)
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S892 Special Subject in Electrical Engineering and Computer Science (New)
Prereq: None
G (Fall, Spring)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S893 Special Subject in Electrical Engineering and Computer Science (New)
Prereq: None
G (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S894 Special Subject in Electrical Engineering and Computer Science (New)
Prereq: None
G (Fall, Spring)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S895 Special Subject in Electrical Engineering and Computer Science (New)
Prereq: None
G (Fall, Spring)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S896 Special Subject in Electrical Engineering and Computer Science (New)
Prereq: None
G (Fall)
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S897 Special Subject in Computer Science
Prereq: Permission of instructor
G (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S898 Special Subject in Computer Science
Prereq: Permission of instructor
G (Fall)
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S899 Special Subject in Computer Science
Prereq: Permission of instructor
G (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S911 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Spring)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum.
Consult Department

6.S912 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum.
Consult Department

6.S913 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall, IAP, Spring)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum.
Consult Department

6.S914 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall, IAP, Spring)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum.
Consult Department

6.S915 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall, IAP, Spring)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum.
Consult Department

6.S916 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall, IAP, Spring)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum.
Consult Department

6.S917 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall, IAP, Spring)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum.
Consult Department

6.S918 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall, IAP, Spring)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum.
Consult Department

6.S919 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (Fall, IAP, Spring)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum.
Consult Department

6.S950 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S951 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Fall)
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S952 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Spring)
3-0-3 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S953 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Spring)
Not offered regularly; consult department
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S954 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Fall)
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S955 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Fall)
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S956 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Spring)
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S960 Special Studies: Electrical Engineering and Computer Science (New)
Prereq: None
G (Fall, Spring)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Opportunity for study of graduate-level topics related to electrical engineering and computer science but not included elsewhere in the curriculum. Registration under this subject normally used for situations involving small study groups. Normal registration is for 12 units. Registration subject to approval of professor in charge.
Consult Department Graduate Office

6.S961 Special Studies: Electrical Engineering and Computer Science (New)
Prereq: None
G (Fall, Spring)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Opportunity for study of graduate-level topics related to electrical engineering and computer science but not included elsewhere in the curriculum. Registration under this subject normally used for situations involving small study groups. Normal registration is for 12 units. Registration subject to approval of professor in charge.
Consult Department Graduate Office

6.S962 Special Studies: Electrical Engineering and Computer Science (New)
Prereq: None
G (Fall, Spring)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Opportunity for study of graduate-level topics related to electrical engineering and computer science but not included elsewhere in the curriculum. Registration under this subject normally used for situations involving small study groups. Normal registration is for 12 units. Registration subject to approval of professor in charge.
Consult Department Graduate Office

6.S963-6.S967 Special Studies: EECS
Prereq: None
G (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Opportunity for study of graduate-level topics related to electrical engineering and computer science but not included elsewhere in the curriculum. Registration under this subject normally used for situations involving small study groups. Normal registration is for 12 units. Registration subject to approval of professor in charge. Consult the department for details.
Consult Department

6.S974 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S975 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Fall)
Not offered regularly; consult department
Units arranged [P/D/F]
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S976 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
G (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S977 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
G (Spring)
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S978 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
G (Spring)
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S979 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
G (Fall)
Units arranged
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S980 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Fall)
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S981 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
G (Fall)
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S982 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
G (Fall)
Not offered regularly; consult department
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S983 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Spring)
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S984 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Spring)
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S985 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Spring)
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S986 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Spring)
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S987 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Spring)
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

6.S988 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Spring)
3-0-9 units
Can be repeated for credit.

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
Consult Department

Common Ground for Computing Education

6.C01 Modeling with Machine Learning: from Algorithms to Applications
Subject meets with 6.C51
Prereq: Calculus II (GIR) and 6.100A; *Coreq: 1.C01, 2.C01, 3.C01[J], or 22.C01*
U (Spring)
3-0-3 units

Focuses on modeling with machine learning methods with an eye towards applications in engineering and sciences. Introduction to modern machine learning methods, from supervised to unsupervised models, with an emphasis on newer neural approaches. Emphasis on the understanding of how and why the methods work from the point of view of modeling, and when they are applicable. Using concrete examples, covers formulation of machine learning tasks, adapting and extending methods to given problems, and how the methods can and should be evaluated. Students taking graduate version complete additional assignments. Students taking graduate version complete additional assignments. Students cannot receive credit without simultaneous completion of a 6-unit disciplinary module. Enrollment may be limited.
R. Barzilay, T. Jaakkola

6.C06[J] Linear Algebra and Optimization (New)
Same subject as 18.C06[J]
Prereq: Calculus II (GIR)
U (Fall)
5-0-7 units. REST
Credit cannot also be received for 18.06, 18.700

See description under subject 18.C06[J].
A. Moitra, P. Parrilo

6.C25[J] Real World Computation with Julia (New)
Same subject as 1.C25[J], 12.C25[J], 16.C25[J], 18.C25[J], 22.C25[J]
Prereq: 6.100A, 18.03, and 18.06
U (Fall)
3-0-9 units

See description under subject 18.C25[J].
A. Edelman, R. Ferrari, B. Forget, C. Leiseron,Y. Marzouk, J. Williams

6.C27[J] Computational Imaging: Physics and Algorithms (New)
Same subject as 2.C27[J], 3.C27[J]
Subject meets with 2.C67[J], 3.C67[J], 6.C67[J]
Prereq: 18.C06[J] and (1.00, 1.000, 2.086, 3.019, or 6.100A)
U (Fall)
3-0-9 units

See description under subject 2.C27[J].
G. Barbastathis, J. LeBeau, R. Ram, S. You

6.C35[J] Interactive Data Visualization and Society
Same subject as 11.C35[J]
Subject meets with 6.C85[J], 11.C85[J]
Prereq: None
U (Spring)
3-1-8 units
Credit cannot also be received for 6.8530, 11.154, 11.454

Covers the design, ethical, and technical skills for creating effective visualizations. Short assignments build familiarity with the data analysis and visualization design process. Weekly lab sessions present coding and technical skills. A final project provides experience working with real-world big data, provided by external partners, in order to expose and communicate insights about societal issues. Students taking graduate version complete additional assignments. Enrollment limited. Enrollment limited.
C. D'Ignazio, A. Satyanarayan, S. Williams

6.C51 Modeling with Machine Learning: from Algorithms to Applications
Subject meets with 6.C01
Prereq: Calculus II (GIR) and 6.100A; *Coreq: 1.C51, 2.C51, 3.C51[J], 22.C51, or SCM.C51*
G (Spring)
3-0-3 units

Focuses on modeling with machine learning methods with an eye towards applications in engineering and sciences. Introduction to modern machine learning methods, from supervised to unsupervised models, with an emphasis on newer neural approaches. Emphasis on the understanding of how and why the methods work from the point of view of modeling, and when they are applicable. Using concrete examples, covers formulation of machine learning tasks, adapting and extending methods to given problems, and how the methods can and should be evaluated. Students taking graduate version complete additional assignments. Students cannot receive credit without simultaneous completion of a 6-unit disciplinary module. Enrollment may be limited.
R. Barzilay, T. Jaakkola

6.C67[J] Computational Imaging: Physics and Algorithms (New)
Same subject as 2.C67[J], 3.C67[J]
Subject meets with 2.C27[J], 3.C27[J], 6.C27[J]
Prereq: 18.C06[J] and (1.00, 1.000, 2.086, 3.019, or 6.100A)
G (Fall)
3-0-9 units

See description under subject 2.C67[J].
G. Barbastathis, J. LeBeau, R. Ram, S. You

6.C85[J] Interactive Data Visualization and Society
Same subject as 11.C85[J]
Subject meets with 6.C35[J], 11.C35[J]
Prereq: None
G (Spring)
3-1-8 units
Credit cannot also be received for 6.8530, 11.154, 11.454

Covers the design, ethical, and technical skills for creating effective visualizations. Short assignments build familiarity with the data analysis and visualization design process. Students participate in hour-long studio reading sessions. A final project provides experience working with real-world big data, provided by external partners, in order to expose and communicate insights about societal issues. Students taking graduate version complete additional assignments.
C. D'Ignazio, A. Satyanarayan, S. Williams