

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-eeecs.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 two core subjects that introduce electrical engineering and computer science, and then systematically build up broad foundations and depth in selected intellectual theme areas that match their individual interests. Laboratory subjects, independent projects, and research provide engagement with principles and techniques of analysis, design, and experimentation in a variety of fields. The department also offers a range of programs that enable students to gain experience in industrial settings, ranging from collaborative industrial projects done on campus to term-long experiences at partner companies.

Graduate study in the department moves students toward mastery of areas of individual interest, through coursework and significant research, often defined in interdisciplinary areas that take advantage of the tremendous range of faculty expertise in the department and, more broadly, across MIT.

Undergraduate Study

For MIT undergraduates, the Department of Electrical Engineering and Computer Science offers several programs leading to the Bachelor of Science:

- 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. It is accredited by the Engineering Accreditation Commission of Accreditation Board for Engineering and Technology (ABET) (<http://www.abet.org>).
- 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 those whose interests cross this traditional boundary. It is accredited by both the Engineering and Computing Accreditation Commissions of ABET.
- 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. It is accredited by both the Engineering and Computing Accreditation Commissions of ABET.
- The 6-7 program (<http://catalog.mit.edu/degree-charts/computer-science-molecular-biology-course-6-7>), offered jointly by the Department of Electrical Engineering and Computer Science and the Department of Biology (Course 7), is for students specializing in computer science and molecular biology. A detailed description of this degree program and its requirements can be found in the section on Interdisciplinary Programs (<http://catalog.mit.edu/interdisciplinary/undergraduate-programs/degrees/computer-science-molecular-biology>).
- The 6-9 program (<http://catalog.mit.edu/degree-charts/computation-cognition-6-9>), offered jointly by the Department of Electrical Engineering and Computer Science and the Department of Biology and the Department of Brain and Cognitive Sciences (Course 9), focuses on the emerging field of computational and engineering approaches to brain science, cognition, and machine intelligence. A detailed description of this degree program and its requirements can be found in the section on Interdisciplinary Programs (<http://catalog.mit.edu/interdisciplinary/undergraduate-programs/degrees/computation-cognition>).
- The 6-14 program (<http://catalog.mit.edu/degree-charts/computer-science-economics-data-science-course-6-14>), offered jointly by the Department of Electrical Engineering and Computer Science and the Department of Economics (Course 14), is for students specializing in computer science, economics, and data science. A detailed description of this degree program and its requirements can be found in the section on Interdisciplinary Programs (<http://catalog.mit.edu/interdisciplinary/undergraduate-programs/degrees/computer-science-economics-data-science>).

interdisciplinary/undergraduate-programs/degrees/computer-science-economics-data-science).

- The 11-6 program (<http://catalog.mit.edu/degree-charts/urban-science-planning-computer-science-11-6>), offered jointly by the Department of Electrical Engineering and Computer Science and the Department of Urban Studies and Planning (Course 11), is for students specializing in urban science and planning with computer science. A detailed description of this degree program and its requirements can be found in the section on Interdisciplinary Programs (<http://catalog.mit.edu/interdisciplinary/undergraduate-programs/degrees/urban-science-planning-computer-science>).

The bachelor's programs in 6-1, 6-2, and 6-3 build on the General Institute Requirements in science and the humanities, and are structured to provide early, hands-on engagement with ideas, activities, and learning that allow students to experience the range and power of electrical engineering and computer science in an integrated way. The required introductory core subject (one of 6.01, 6.02, 6.03, and 6.08) involves substantial work in the laboratory. This subject is complemented by a mathematics subject, and followed by a choice of three foundation courses from a set of subjects that provide the basis for subsequent specialization. Students define their specialization by selecting three to four header subjects, two advanced undergraduate subjects, and one to two EECS elective subjects from an extensive set of possibilities. The flexibility in these choices permits students considerable latitude in shaping their program to match diverse interests, while ensuring depth and mastery in a few selected areas.

The joint bachelor's programs in 6-7 provides an interdepartmental curriculum involving rigorous training in both molecular biology and computer science. Students begin with introductory courses in math, chemistry, programming, and lab skills. Students 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.

The joint bachelor's program in 6-9 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, and computational approaches to cognition and intelligence.

The joint bachelor's program in 6-14 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. From there, students take two subjects in data science, two in intermediate economics, and three elective subjects from data science and economics theory.

All students in 6-1, 6-2, 6-3, 6-7, or 6-9 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 degrees.

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:

6.0001	Introduction to Computer Science Programming in Python	6
6.0002	Introduction to Computational Thinking and Data Science	6
6.01	Introduction to EECS via Robotics	12
6.02	Introduction to EECS via Communication Networks	12
6.08	Introduction to EECS via Interconnected Embedded Systems	12

Basic Level

Select up to 63 units of the following:

6.004	Computation Structures	12
6.008	Introduction to Inference	12
6.034	Artificial Intelligence	12
6.041	Introduction to Probability	12
6.042[J]	Mathematics for Computer Science	12
18.200	Principles of Discrete Applied Mathematics	15
18.200A	Principles of Discrete Applied Mathematics	12
18.211	Combinatorial Analysis	12

Algorithms-intensive

6.006	Introduction to Algorithms	12
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Software-intensive

6.009	Fundamentals of Programming	12
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Advanced Level

Select at least 12 units of the following:

6.033	Computer Systems Engineering	12
6.036	Introduction to Machine Learning	12
6.045[J]	Computability and Complexity Theory	12
6.046[J]	Design and Analysis of Algorithms	12

6.047	Computational Biology: Genomes, Networks, Evolution	12
6.419[J]	Statistics, Computation and Applications	12
6.801	Machine Vision	12
6.802[J]	Computational Systems Biology: Deep Learning in the Life Sciences	12
6.803	The Human Intelligence Enterprise	12
6.804[J]	Computational Cognitive Science	12
6.806	Advanced Natural Language Processing	12
6.811[J]	Principles and Practice of Assistive Technology	12
6.814	Database Systems	12
6.815	Digital and Computational Photography	12
6.819	Advances in Computer Vision	12
6.837	Computer Graphics	12
6.905	Large-scale Symbolic Systems	12
18.404	Theory of Computation	12
Algorithms-intensive		
6.046[J]	Design and Analysis of Algorithms	12
Software-intensive		
6.031	Elements of Software Construction	15
6.035	Computer Language Engineering	12
6.141[J]	Robotics: Science and Systems	12
6.170	Software Studio	15
6.172	Performance Engineering of Software Systems	18
6.175	Constructive Computer Architecture	12
6.809[J]	Interactive Music Systems	12
6.816	Multicore Programming	12

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.

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-eeecs.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 for students interested in the analysis and application of computational approaches to designing and operating engineered systems. The curriculum is designed with a common core serving all engineering disciplines and an elective component focusing on specific applications. Current MIT graduate students may pursue a 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://lgo.mit.edu>) 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. For additional information, see the program description (<http://catalog.mit.edu/schools/mit-schwarzman-college-computing/data-systems-society>) under the Institute for Data, Systems, and Society.

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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

Tommi S. Jaakkola, PhD
Thomas Siebel Professor
Professor of Electrical Engineering and Computer Science
Affiliate Faculty, Institute for Data, Systems, and Society

Daniel Jackson, PhD
Professor of Computer Science and Engineering

Patrick Jaillet, PhD
Dugald C. Jackson Professor
Professor of Electrical Engineering and Computer Science
Core Faculty, Institute for Data, Systems, and Society

M. Frans Kaashoek, PhD
Charles A. Piper (1935) Professor
Professor of Electrical Engineering and Computer Science

Leslie P. Kaelbling, PhD
Panasonic Professor
Professor of Computer Science and Engineering

David R. Karger, PhD
Professor of Computer Science and Engineering

Dina Katabi, PhD
Andrew (1956) and Erna Viterbi 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

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

Hae-Seung Lee, PhD
Advanced Television and Signal Processing Professor
Professor of Electrical Engineering

Steven B. Leeb, PhD
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

Barbara H. Liskov, PhD
Institute Professor Post-Tenure
Professor Post-Tenure of Computer Science

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

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

Samuel R. Madden, PhD
College of Computing Distinguished Professor of Computing
Professor of Computer Science and Engineering
(On leave, fall)

Aleksander Madry, PhD
Professor of Computer Science

Thomas L. Magnanti, PhD
Institute Professor
Professor of Operations Research
Professor of Electrical Engineering
Member, Institute for Data, Systems, and Society

Wojciech Matusik, PhD
Professor of Electrical Engineering and Computer Science

Muriel Médard, ScD
Cecil H. Green Professor
Professor of Electrical Engineering and Computer Science

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

Silvio Micali, PhD
Ford Foundation Professor of Engineering
Professor of Computer Science and Engineering
(On leave, fall)

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

Sanjoy K. Mitter, PhD
Professor Post-Tenure of Electrical Engineering
Core Faculty, Institute for Data, Systems, and Society

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

Joel Moses, PhD
Institute Professor Post-Tenure
Professor Post-Tenure of Electrical Engineering and Computer Science
Affiliate Faculty, Institute for Data, Systems, and Society

Alan V. Oppenheim, PhD
Ford 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
Professor of Electrical Engineering

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

David J. Perreault, PhD
Joseph F. and Nancy P. Keithley Professor
Professor of Electrical Engineering and Computer Science

Rajeev J. Ram, PhD
Professor of Electrical Engineering

L. Rafael Reif, PhD
President
Professor of Electrical Engineering

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

Ronald L. Rivest, PhD
Institute Professor
Professor of Computer Science and Engineering

Ronitt Rubinfeld, PhD
Edwin Sibley Webster Professor
Professor of Computer Science and Engineering

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

Martin A. Schmidt, PhD
Ray and Maria Stata Professor
Professor of Electrical Engineering and Computer Science
Provost

Devavrat Shah, PhD
Professor of Electrical Engineering and Computer Science
Associate Director, Institute for Data, Systems, and Society
Core Faculty, Institute for Data, Systems, and Society
(On leave, spring)

Jeffrey H. Shapiro, PhD
Julius A. Stratton Professor Post-Tenure
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
Professor Post-Tenure of Electrical Engineering
Core Faculty, Institute for Medical Engineering and Science

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

Collin M. Stultz, MD, PhD
Professor in Biomedical Engineering
Core Faculty, Institute for Medical Engineering and Science
(On leave, fall)

Gerald Jay Sussman, PhD
Panasonic Professor
Professor of Electrical Engineering

Peter Szolovits, PhD
Professor of Computer Science and Engineering
Affiliate Faculty, Institute for Medical Engineering and Science
(On leave)

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
Professor of Electrical Engineering
Associate Director, Institute for Data, Systems, and Society
(On leave)

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

Cardinal Warde, PhD
Professor of Electrical Engineering

Jacob K. White, PhD
Cecil H. Green Professor
Professor of Electrical Engineering

Ryan Williams, PhD
Professor of Electrical Engineering and Computer Science

Alan S. Willsky, PhD
Edwin Sibley Webster Professor Post-Tenure
Professor Post-Tenure of Electrical Engineering and Computer Science
Core Faculty, Institute for Data, Systems, and Society

Gregory W. Wornell, PhD
Sumitomo Electric Industries Professor in Engineering
Professor of Electrical Engineering
Affiliate Faculty, Institute for Data, Systems, and Society
(On leave, spring)

Nickolai Zeldovich, PhD
Professor of Electrical Engineering and Computer Science

Lizhong Zheng, PhD
Professor of Electrical Engineering

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

Associate Professors

Fadel Adib, PhD
Doherty Chair in Ocean Utilization
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

Guy Bresler, PhD
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Core Faculty, Institute for Data, Systems, and Society

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Affiliate Faculty, Institute for Data, Systems, and Society

Adam Chlipala, PhD
Associate Professor of Electrical Engineering and Computer Science

Dirk Robert Englund, 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

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

Stefanie Sabrina Jegelka, ScD
X-Window Consortium Career Development Professor
Associate Professor of Electrical Engineering and Computer Science
Affiliate Faculty, Institute for Data, Systems, and Society
(On leave, fall)

Tim Kraska, PhD
ITT Career Development Professor
Associate Professor of Electrical Engineering and Computer Science
(On leave)

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

Timothy K. Lu, MD, PhD
Associate Professor of Electrical Engineering
Associate Professor of Biological Engineering

William D. Oliver, PhD
Associate Professor of Electrical Engineering and Computer Science

Yury Polyanskiy, PhD
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Core Faculty, Institute for Data, Systems, and Society

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

Max M. Shulaker, PhD
Associate Professor of Electrical Engineering and Computer Science

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

David Sontag, PhD
Von Helmholtz Professor of Medical Engineering
Associate Professor of Electrical Engineering and Computer Science
Core Faculty, Institute for Medical Engineering and Science

Suvrit Sra, PhD
Esther and Harold Edgerton Career Development Professor
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Core Faculty, Institute for Data, Systems, and Society
(On leave, fall)

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

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

Vinod Vaikuntanathan, PhD
Associate Professor of Electrical Engineering and Computer Science
(On leave, fall)

Virginia Williams, PhD
Associate Professor of Electrical Engineering and Computer Science

Assistant Professors

Pulkit Agrawal, PhD
Steven G. (1968) and Renée Finn Career Development Professor
Assistant Professor of Electrical Engineering and Computer Science

Jacob Andreas, PhD
X-Window Consortium Career Development Professor
Assistant Professor of Electrical Engineering and Computer Science

Adam Belay, PhD
Assistant Professor of Electrical Engineering and Computer Science

Michael J. Carbin, PhD
Assistant Professor of Electrical Engineering and Computer Science

Henry Carrigan-Gibbs, PhD
Assistant Professor of Electrical Engineering and Computer Science

YuFeng Chen, PhD
D. Reid Weedon Jr. '41 Career Development Professor
Assistant Professor of Electrical Engineering and Computer Science

Manya Ghobadi, PhD
TIBCO Career Development Professor
Assistant Professor of Electrical Engineering and Computer Science

Song Han, PhD
Robert J. Shillman (1974) Career Development Professor
Assistant Professor of Electrical Engineering and Computer Science

Phillip John Isola, PhD
Bonnie and Marty (1964) Tenenbaum Career Development Professor
Assistant Professor of Electrical Engineering and Computer Science

Stefanie Mueller, PhD
Assistant Professor of Electrical Engineering and Computer Science
Assistant Professor of Mechanical Engineering
(On leave, fall)

Anand Natarajan, PhD
Assistant Professor of Electrical Engineering and Computer Science

Farnaz Niroui, PhD
E.E. Landsman (1958) Career Development Professor
Assistant Professor of Electrical Engineering and Computer Science

Jelena Notaros, PhD
Assistant Professor of Electrical Engineering and Computer Science

Kevin O'Brien, PhD
Emanuel E. Landsman (1958) Career Development Professor
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Jonathan M. Ragan-Kelley, PhD
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Negar Reiskarimian, PhD
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Assistant Professor of Electrical Engineering and Computer Science

Arvind Satyanarayan, PhD
NBX Career Development Professor
Assistant Professor of Electrical Engineering and Computer Science

Julian Shun, PhD
Douglas Ross (1954) Career Development Professor
Assistant Professor of Software Technology

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

Professors of the Practice

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

Adjunct Professors

David J. DeWitt, PhD
Adjunct Professor of Computer Science and Engineering

Butler W. Lampson, PhD
Adjunct Professor of Computer Science and Engineering

Michael Stonebraker, PhD
Adjunct Professor of Computer Science and Engineering

Adjunct Associate Professors

Yael Kalai, PhD
Adjunct Associate Professor of Electrical Engineering and Computer Science

Senior Lecturers

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

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

Gim P. Hom, MS, MS, EE
Senior Lecturer in Electrical Engineering and Computer Science

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

Lecturers

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

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

Iddo Drori, PhD
Lecturer in Electrical Engineering and Computer Science

Max Goldman, PhD
Principal 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

Kimberle Koile, PhD
Lecturer in Electrical Engineering and Computer Science

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

Technical Instructors

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

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

Scott Poesse, AA
Technical Instructor of Electrical Engineering and Computer Science

Professors Emeriti

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 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

Murray Eden, PhD
Professor Emeritus of Electrical Engineering

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

G. David Forney, ScD
Adjunct Professor Emeritus of Electrical Engineering
Core Faculty, Institute for Data, Systems, and Society

Lawrence S. Frishkopf, PhD
Professor Emeritus of Electrical Engineering and Computer Science

Robert G. Gallager, ScD
Professor Emeritus of Electrical Engineering

Carl Eddie Hewitt, PhD
Associate 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

Robert S. Kennedy, ScD
Professor Emeritus of Electrical Engineering

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

Paul L. Penfield Jr, PhD
Dugald C. Jackson Professor Emeritus
Professor Emeritus of Electrical Engineering

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

Herbert Harold Sawin, PhD
Professor Emeritus of Chemical Engineering
Professor Emeritus of Electrical Engineering

Joel E. Schindall, PhD
Bernard M. Gordon Professor of the Practice Emeritus

Stephen D. Senturia, PhD
Professor Emeritus of Electrical Engineering

Henry Ignatius Smith, PhD

Joseph F. and Nancy P. Keithley Professor Emeritus
Professor Emeritus of Electrical Engineering

Richard D. Thornton, ScD

Professor Emeritus of Electrical Engineering

Stephen A. Ward, PhD

Professor Emeritus of Computer Science and Engineering

Thomas F. Weiss, PhD

Professor Emeritus of Electrical and Bioengineering

Professor Emeritus of Health Sciences and Technology

Gerald L. Wilson, PhD

Vannevar Bush Professor Emeritus

Professor Emeritus of Electrical Engineering

Professor Emeritus of Mechanical Engineering

Markus Zahn, ScD

Thomas and Gerd Perkins Professor Emeritus

Professor Emeritus of Electrical Engineering

Basic Undergraduate Subjects

6.0001 Introduction to Computer Science Programming in Python

Prereq: None

U (Fall, Spring; first half of term)

3-0-3 units

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 6.0001 and 6.0002 counts as REST subject. Final given in the seventh week of the term.

A. Bell, J. V. Guttag

6.0002 Introduction to Computational Thinking and Data Science

Prereq: 6.0001 or permission of instructor

U (Fall, Spring; second half of term)

3-0-3 units

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 6.0001 and 6.0002 counts as REST subject.

A. Bell, J. V. Guttag

6.Soo Special Subject in Electrical Engineering and Computer Science (New)

Prereq: None

U (Fall, Spring)

Units arranged

Covers subject matter not offered in the regular curriculum. Consult department to learn of offerings for a particular term.

A. Bell, W. E. L. Grimson, J. V. Guttag

6.002 Circuits and Electronics

Prereq: Physics II (GIR); Coreq: 2.087 or 18.03

U (Fall, Spring)

3-2-7 units. REST

Fundamentals of linear systems and abstraction modeling through lumped electronic circuits. Linear networks involving independent and dependent sources, resistors, capacitors and inductors.

Extensions to include nonlinear resistors, switches, transistors, operational amplifiers and transducers. Dynamics of first- and second-order networks; 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

6.003 Signal Processing

Prereq: Calculus I (GIR) and 6.0001

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

6.004 Computation Structures

Prereq: Physics II (GIR) and 6.0001

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.

Arvind, S. Z. Hanono Wachman, D. Sanchez

6.006 Introduction to Algorithms

Prereq: 6.042[J] and (6.0001 or Coreq: 6.009)

U (Fall, Spring)

4-0-8 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***6.008 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***6.009 Fundamentals of Programming**

Prereq: 6.0001

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***6.01 Introduction to EECS via Robotics**

Prereq: 6.0001 or permission of instructor

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: U (Spring)

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***6.011 Signals, Systems and Inference**

Prereq: 6.003 and (6.008, 6.041, or 18.600)

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.

A. V. Oppenheim, G. C. Verghese

6.012 Nanoelectronics and Computing Systems

Prereq: 6.002

U (Fall, 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

6.013 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. 6.002 and 6.003 are recommended but not required.

K. O'Brien, L. Daniel

6.014 Electromagnetic Fields, Forces and Motion

Subject meets with 6.640

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. L. Kirtley, Jr., J. H. Lang

6.02 Introduction to EECS via Communication Networks

Prereq: 6.0001

U (Fall)

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

6.021[J] Cellular Neurophysiology and Computing

Same subject as 2.791[J], 9.21[J], 20.370[J]

Subject meets with 2.794[J], 6.521[J], 9.021[J], 20.470[J], HST.541[J]

Prereq: (Physics II (GIR), 18.03, and (2.005, 6.002, 6.003, 10.301, or 20.110[J])) or permission of instructor

U (Fall)

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. In person not required. Preference to juniors and seniors.

J. Han, T. Heldt

6.022[J] Quantitative and Clinical Physiology

Same subject as 2.792[J], HST.542[J]

Subject meets with 2.796[J], 6.522[J]

Prereq: Physics II (GIR), 18.03, or permission of instructor

U (Spring)

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

6.023[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

6.024[J] Molecular, Cellular, and Tissue Biomechanics

Same subject as 2.797[J], 3.053[J], 20.310[J]

Prereq: Biology (GIR), (2.370 or 20.110[J]), and (3.016B or 18.03)

U (Spring)

4-0-8 units

See description under subject 20.310[J].

M. Bathe, A. Grodzinsky

6.025[J] Medical Device Design

Same subject as 2.750[J]

Subject meets with 2.75[J], 6.525[J], HST.552[J]

Prereq: 2.008, 6.101, 6.111, 6.115, 22.071, or permission of instructor

U (Fall)

3-0-9 units

See description under subject 2.750[J]. Enrollment limited.

A. H. Slocum, G. Hom, E. Roche, N. C. Hanumara

6.026[J] Biomedical Signal and Image Processing

Same subject as HST.482[J]

Subject meets with 6.555[J], 16.456[J], HST.582[J]

Prereq: (6.041 or permission of instructor) and (2.004, 6.003, 16.002, or 18.085)

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: U (Spring)

3-1-8 units

See description under subject HST.482[J].

J. Greenberg, E. Adalsteinsson, W. Wells

6.027[J] Biomolecular Feedback Systems

Same subject as 2.180[J]

Subject meets with 2.18[J], 6.557[J]

Prereq: Biology (GIR), 18.03, or permission of instructor

U (Spring)

3-0-9 units

See description under subject 2.180[J].

D. Del Vecchio

6.03 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

6.031 Elements of Software Construction

Prereq: 6.009

U (Fall, Spring)

5-0-10 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

6.033 Computer Systems Engineering

Prereq: 6.004 and 6.009

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

6.034 Artificial Intelligence

Prereq: 6.0001

U (Fall)

4-3-5 units

Credit cannot also be received for 6.844

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

6.035 Computer Language Engineering

Prereq: 6.004 and 6.031

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

6.036 Introduction to Machine Learning

Prereq: Calculus II (GIR) and (6.0001 or 6.01)

U (Fall, Spring)

4-0-8 units

Credit cannot also be received for 6.862

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. Students taking graduate version complete additional assignments. Meets with 6.862 when offered concurrently. Recommended prerequisites: 6.006 and 18.06. Enrollment may be limited.
D. S. Boning, P. Jaillet, L. P. Kaelbling

6.037 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***6.041 Introduction to Probability**

Subject meets with 6.431

Prereq: Calculus II (GIR)

U (Fall, Spring)

4-0-8 units. REST

Credit cannot also be received for 15.079, 15.0791, 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***6.042[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***6.045[J] Computability and Complexity Theory**

Same subject as 18.400[J]

Prereq: 6.042[J]

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***6.046[J] Design and Analysis of Algorithms**

Same subject as 18.410[J]

Prereq: 6.006

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***6.047 Computational Biology: Genomes, Networks, Evolution**

Subject meets with 6.878[J], HST.507[J]

Prereq: (Biology (GIR), 6.006, and 6.041B) 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

6.049[J] Evolutionary Biology: Concepts, Models and Computation

Same subject as 7.33[J]

Prereq: (6.0001 and 7.03) or permission of instructor

U (Spring)

3-0-9 units

See description under subject 7.33[J].

R. Berwick, D. Bartel

6.050[J] Information, Entropy, and Computation

Same subject as 2.110[J]

Prereq: Physics I (GIR)

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: U (Spring)

3-0-6 units

See description under subject 2.110[J].

P. Penfield, Jr.

6.057 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

6.058 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

6.061 Introduction to Electric Power Systems

Subject meets with 6.690

Prereq: 6.002 and 6.013

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: U (Spring)

3-0-9 units

Electric circuit theory with application to power handling electric circuits. Modeling and behavior of electromechanical devices, including magnetic circuits, motors, and generators. Operational fundamentals of synchronous. Interconnection of generators and motors with electric power transmission and distribution circuits. Power generation, including alternative and sustainable sources. Incorporation of energy storage in power systems. Students taking graduate version complete additional assignments.

J. L. Kirtley, Jr.

6.070[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, meters (voltage, resistance inductance, capacitance, etc.), and signal generators. Emphasizes individual instruction and development of skills, such as soldering, assembly, and troubleshooting. Students design, build, and keep a small electronics project to put their new knowledge into practice. Intended for students with little or no previous background in electronics. In person not required. Enrollment may be limited.

J. Bales

6.073[J] Creating Video Games

Same subject as CMS.611[J]

Prereq: 6.01, CMS.301, or CMS.608

U (Spring)

3-3-6 units. HASS-A

See description under subject CMS.611[J]. Limited to 24.

P. Tan, S. Verrilli, R. Eberhardt, A. Grant

6.o8 Introduction to EECS via Interconnected Embedded SystemsPrereq: 6.0001; Coreq: *Physics II (GIR)*

U (Spring)

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 final project, student teams design and demo their own cloud-connected IoT system. In person not required. Enrollment limited; preference to first- and second-year students.

*S. Mueller, J. D. Steinmeyer, J. Voldman***6.So62 Special Subject in Electrical Engineering and Computer Science**

Prereq: None

U (Fall, Spring)

Units arranged

Can be repeated for credit.

Basic undergraduate subjects not offered in the regular curriculum.
Consult Department

6.So63 Special Subject in Electrical Engineering and Computer Science

Prereq: None

U (Fall, Spring)

Units arranged

Can be repeated for credit.

Basic undergraduate subjects not offered in the regular curriculum.
Consult Department

6.So76 Special Subject in Electrical Engineering and Computer Science

Prereq: Permission of instructor

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.So77 Special Subject in Electrical Engineering and Computer Science

Prereq: Permission of instructor

U (Fall; second half of term)

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.So78 Special Subject in Electrical Engineering and Computer Science**

Prereq: Permission of instructor

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.So79 Special Subject in Electrical Engineering and Computer Science**

Prereq: Permission of instructor

U (Fall, 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.So80 Special Subject in Electrical Engineering and Computer Science**

Prereq: Permission of instructor

U (Fall, 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.So81 Special Subject in Electrical Engineering and Computer Science**

Prereq: Permission of instructor

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.So82 Special Subject in Electrical Engineering and Computer Science

Prereq: Permission of instructor
U (Fall, Spring; second half of term)
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.So83 Special Subject in Electrical Engineering and Computer Science

Prereq: Permission of instructor
U (Fall, 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.So84 Special Subject in Electrical Engineering and Computer Science

Prereq: Permission of instructor
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.So85 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.So86 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.So87 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.So88 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.So89 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)

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.S092 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.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)

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.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)

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.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 (Fall, 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

Undergraduate Laboratory Subjects

6.100 Electrical Engineering and Computer Science Project

Prereq: None

U (Fall, Spring, Summer)

Units arranged

Can be repeated for credit.

Individual experimental work related to electrical engineering and computer science. Student must make arrangements with a project supervisor and file a proposal endorsed by the supervisor. Departmental approval required. Written report to be submitted upon completion of work.

Consult Department Undergraduate Office

6.101 Introductory Analog Electronics Laboratory

Prereq: 6.002

U (Spring)

2-9-1 units. Institute LAB

Introductory 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

6.111 Introductory Digital Systems Laboratory

Prereq: 6.002, 6.08, or 16.004

U (Fall)

3-7-2 units. Institute LAB

Introduces digital systems with lectures and labs on logic, flip flops, FPGAs, counters, timing, synchronization, and finite-state machines. Includes overview of accelerometers, gyros, time of flight and other modern sensors. Prepares students for the design and implementation of a final project of their choice: games, music, digital filters, wireless communications, video, or graphics. Extensive use of Verilog for describing and implementing digital logic designs. In person not required.

G. P. Hom, J. Steinmeyer, A. P. Chandrakasan

6.115 Microcomputer Project Laboratory

Subject meets with 6.1151

Prereq: 6.002, 6.003, or 6.004

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

6.1151 Microcomputer Project Laboratory - Independent Inquiry

Subject meets with 6.115

Prereq: 6.002, 6.003, or 6.004

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 6.1151 expand the scope of their laboratory project.

S. B. Leeb

6.117 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

6.123[J] Bioinstrumentation Project Lab

Same subject as 20.345[J]

Prereq: 20.309[J], (Biology (GIR) and (2.004 or 6.003)), or permission of instructor

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: U (Spring)

2-7-3 units

See description under subject 20.345[J]. Enrollment limited; preference to Course 20 majors and minors.

E. Boyden, M. Jonas, S. F. Nagle, P. So, S. Wasserman, M. F. Yanik

6.129[J] Biological Circuit Engineering Laboratory (New)

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

6.131 Power Electronics Laboratory

Subject meets with 6.1311, 6.330

Prereq: 6.002 or 6.003

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 6.1311 expand the scope of their laboratory project.

S. B. Leeb

6.1311 Power Electronics Laboratory - Independent Inquiry

Subject meets with 6.131, 6.330

Prereq: 6.002 or 6.003

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

6.141[J] Robotics: Science and Systems

Same subject as 6.405[J]

Prereq: ((1.00 or 6.0001) and (2.003[J], 6.006, 6.009, or 6.06)) 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 world. Students engage in extensive written and oral communication exercises. Enrollment limited.

L. Carlone, S. Karaman

6.146 Mobile Autonomous Systems Laboratory: MASLAB

Prereq: None

U (IAP)

Not offered regularly; consult department

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

6.147 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

6.148 Web Lab: A Web Programming Class and Competition

Prereq: None

U (IAP)

1-0-5 units

Can be repeated for credit.

Student teams design and build web applications. Lectures cover version control, HTML, CSS, and JavaScript. Prior experience unnecessary as instructors and industry professionals teach both basic and advanced material. Teams present their projects in competition for prizes awarded by a judging panel of industry experts.

Staff

6.150 Mobile Applications Competition

Prereq: Permission of instructor

U (IAP)

Not offered regularly; consult department

2-2-2 units

Can be repeated for credit.

Student teams design and build an Android application based on a given theme. Lectures and labs led by experienced students and leading industry experts, covering the basics of Android development, concepts and tools to help participants build great apps. Contest culminates with a public presentation in front of a judging panel comprised of professional developers and MIT faculty. Prizes awarded. Enrollment limited.

Staff

6.151 iOS Game Design and Development Competition

Prereq: None

U (IAP)

Not offered regularly; consult department

2-2-2 units

Introduction to iOS game design and development for students already familiar with object-oriented programming. Provides a set of basic tools (Objective-C and Cocos2D) and exposure to real-world issues in game design. Working in small teams, students complete a final project in which they create their own iPhone game. At the end of IAP, teams present their games in competition for prizes awarded by a judging panel of gaming experts.

Staff

6.152[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. Michel, J. Scholvin

6.161 Modern Optics Project Laboratory

Prereq: 6.003

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: U (Fall)

3-5-4 units. Institute LAB

Credit cannot also be received for 6.637

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

6.163 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

6.170 Software Studio

Prereq: 6.031 and 6.042[J]

U (Fall)

4-9-2 units

Provides design-focused instruction on how to build software applications. Design topics include classic human-computer interaction (HCI) design tactics (need finding, heuristic evaluation, prototyping, user testing), conceptual design (modeling and evaluating constituent concepts), abstract data modeling, and visual design. Implementation topics include functional programming in Javascript, reactive front-ends, web services, and databases. Students work in teams on term-long projects in which they construct applications of social value.

D. N. Jackson, A. Satyanarayan

6.172 Performance Engineering of Software Systems

Prereq: 6.004, 6.006, and 6.031

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

6.175 Constructive Computer Architecture

Prereq: 6.004

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: U (Fall)

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

6.176 Pokerbots Competition

Prereq: None

U (IAP)

1-0-5 units

Can be repeated for credit.

Build autonomous poker players and acquire 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

6.178 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 6.005. Enrollment limited.

Staff

6.179 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

6.182 Psychoacoustics Project Laboratory

Prereq: None

U (Spring)

Not offered regularly; consult department

3-6-3 units. Institute LAB

Introduces the methods used to measure human auditory abilities. Discusses auditory function, principles of psychoacoustic measurement, models for psychoacoustic performance, and experimental techniques. Project topics: absolute and differential auditory sensitivity, operating characteristics of human observers, span of auditory judgment, adaptive measurement procedures, and scaling sensory magnitudes. Knowledge of probability helpful. Students engage in extensive written and oral communication exercises.

L. D. Braida

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)

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.S191 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.

Consult Department

6.S192 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.

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 (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.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

Senior Projects

6.UAP Undergraduate Advanced Project

Prereq: 6.UAT

U (Fall, IAP, Spring, Summer)

0-6-0 units

Can be repeated for credit.

Research project for those EECS students whose curriculum requires a senior project. To be arranged by the student and an appropriate MIT faculty member. Students who register for this subject must consult the department undergraduate office. Students engage in extensive written communications exercises.

Consult Department Undergraduate Office

6.UAR Seminar in Undergraduate Advanced Research

Prereq: 6.UR and 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, 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, Spring)

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. In person not required. Enrollment may be limited.

T. L. Eng

Advanced Undergraduate Subjects and Graduate Subjects by Area

Systems Science and Control Engineering

6.207[J] Networks

Same subject as 14.15[[]]

Prereq: 6.041 or 14.30

U (Spring)

4-0-8 units. HASS-S

See description under subject 14.15[[]].

A. Wolitzky

6.215 Optimization Methods

Subject meets with 6.255[[]], 15.093[[]], IDS.200[[]]

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

6.231 Dynamic Programming and Reinforcement Learning

Prereq: 18.600 or 6.041

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

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

6.241[J] Dynamic Systems and Control

Same subject as 16.338[[]]

Prereq: 6.003 and 18.06

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: 6.302.

M. A. Dahleh, A. Megretski

6.244[J] Graphical Models: A Geometric, Algebraic, and Combinatorial Perspective

Same subject as IDS.136[[]]

Prereq: 6.431 and 18.06

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

3-0-9 units

See description under subject IDS.136[[]].

C. Uhler

6.245 Multivariable Control Systems

Prereq: 6.241[[]] 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

6.246, 6.247 Advanced Topics in Control

Prereq: Permission of instructor

G (Spring)

3-0-9 units

Can be repeated for credit.

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

Consult Department

6.248, 6.249 Advanced Topics in Numerical Methods

Prereq: Permission of instructor

G (Fall, Spring)

Not offered regularly; consult department

3-0-9 units

Can be repeated for credit.

Advanced study of topics in numerical methods. Specific focus varies from year to year.

Consult Department

6.251[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; integer programming; interior point algorithms for linear programming; and introduction to combinatorial optimization and NP-completeness.

J. N. Tsitsiklis, D. Bertsimas

6.252[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

6.254 Game Theory with Engineering Applications

Prereq: 6.431

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

6.255[J] Optimization Methods

Same subject as 15.093[J], IDS.200[J]

Subject meets with 6.215

Prereq: 18.06

G (Fall)

4-0-8 units

See description under subject 15.093[J].

D. Bertsimas, P. Parrilo

6.256[J] Algebraic Techniques and Semidefinite Optimization

Same subject as 18.456[J]

Prereq: 6.251[J] or 15.093[J]

Acad Year 2020-2021: G (Spring)

Acad Year 2021-2022: Not offered

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***6.260, 6.261 Advanced Topics in Communications**

Prereq: Permission of instructor

G (Fall, Spring)

Not offered regularly; consult department

3-0-9 units

Can be repeated for credit.

Advanced study of topics in communications. Specific focus varies from year to year.

*Consult Department***6.262 Discrete Stochastic Processes**

Prereq: 6.431 or 18.204

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***6.263[J] Data-Communication Networks**

Same subject as 16.37[J]

Prereq: 6.041 or 18.204

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***6.265[J] Discrete Probability and Stochastic Processes**

Same subject as 15.070[J]

Prereq: 6.431, 6.436[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***6.267 Heterogeneous Networks: Architecture, Transport, Protocols, and Management**

Prereq: 6.041 or 6.042[J]

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: 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

6.268 Network Science and Models

Prereq: 6.431 and 18.06

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***Electronics, Computers, and Systems****6.301 Solid-State Circuits**

Subject meets with 6.321

Prereq: 6.002

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, and translinear circuits. Provides practical experience through various lab exercises, including a broadband amplifier design and characterization. Students taking graduate version complete additional assignments.

*H.-S. Lee, R. Han***6.302 Feedback System Design**

Subject meets with 6.320

Prereq: Physics II (GIR) and (2.087 or 18.03)

U (Spring)

4-4-4 units

Learn-by-design introduction to modeling and control of discrete- and continuous-time systems, from classical analytical techniques to modern computational strategies. Topics include modeling (difference/differential equations, natural frequencies, transfer functions, frequency response, impedances); performance metrics (stability, tracking, disturbance rejection); classical design (root-locus, PID, lead-lag); state-space (ABCD matrices, pole placement, LQR, observers); and data-driven design (regression, identification, model-based control). Students apply concepts introduced in lectures and online assignments to design labs that include discussion-based checkoffs. In lab, students use circuits, sensors, actuators, and a microcontroller to design, build and test controllers for, e.g., propeller-actuated positioners, magnetic levitators, and two-wheel balancers. Students taking graduate version complete additional assignments.

*J. K. White***6.320 Feedback System Design**

Subject meets with 6.302

Prereq: Physics II (GIR) and (2.087 or 18.03)

G (Spring)

4-4-4 units

Learn-by-design introduction to modeling and control of discrete- and continuous-time systems, from classical analytical techniques to modern computational strategies. Topics include modeling (difference/differential equations, natural frequencies, transfer functions, frequency response, impedances); performance metrics (stability, tracking, disturbance rejection); classical design (root-locus, PID, lead-lag); state-space (ABCD matrices, pole placement, LQR, observers); and data-driven design (regression, identification, model-based control). Students apply concepts introduced in lectures and online assignments to design labs that include discussion-based checkoffs. In lab, students use circuits, sensors, actuators, and a microcontroller to design, build and test controllers for, e.g., propeller-actuated positioners, magnetic levitators, and two-wheel balancers. Students taking graduate version complete additional assignments.

J. K. White

6.321 Solid-State Circuits

Subject meets with 6.301

Prereq: 6.002

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, and translinear circuits. Provides practical experience through various lab exercises, including a broadband amplifier design and characterization. Students taking graduate version complete additional assignments.

H.-S. Lee, R. Han

6.330 Power Electronics Laboratory (New)

Subject meets with 6.131, 6.1311

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

6.332, 6.333 Advanced Topics in Circuits

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 circuits. Specific focus varies from year to year. Consult department for details.

Consult Department

6.334 Power Electronics

Prereq: 6.012

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

6.335[J] Fast Methods for Partial Differential and Integral Equations

Same subject as 18.336[J]

Prereq: 6.336[J], 16.920[J], 18.085, 18.335[J], or permission of instructor

G (Fall)

3-0-9 units

See description under subject 18.336[J].

K. Burns

6.336[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 and programming (e.g., MATLAB or Python) helpful.

L. Daniel

6.337[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].
S. Johnson

6.338[J] Parallel Computing and Scientific Machine Learning

Same subject as 18.337[J]
 Prereq: 18.06, 18.700, or 18.701
 G (Fall)
 3-0-9 units

See description under subject 18.337[J].
C. Rackauckas

6.339[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].
Q. Wang, S. Groth

6.341 Discrete-Time Signal Processing

Prereq: 6.011
 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

6.344 Digital Image Processing

Prereq: 6.003 and 6.431
 Acad Year 2020-2021: Not offered
 Acad Year 2021-2022: G (Spring)
 3-0-9 units

Digital images as two-dimensional signals. Digital signal processing theories used for digital image processing, including one-dimensional and two-dimensional convolution, Fourier transform, discrete Fourier transform, and discrete cosine transform. Image processing basics. Image enhancement. Image restoration. Image coding and compression. Video processing including video coding and compression. Additional topics in image and video processing.
J. S. Lim

6.345[J] Spoken Language Processing

Same subject as HST.728[J]
 Prereq: 6.011 and 6.036
 Acad Year 2020-2021: Not offered
 Acad Year 2021-2022: G (Spring)
 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 opened-ended term project.

J. R. Glass

6.347, 6.348 Advanced Topics in Signals and Systems

Prereq: Permission of instructor
 G (Fall, Spring)
 Not offered regularly; consult department
 3-0-9 units
 Can be repeated for credit.

Advanced study of topics in signals and systems. Specific focus varies from year to year.
Consult Department

6.374 Analysis and Design of Digital Integrated Circuits

Prereq: 6.004 and 6.012

G (Fall)

3-3-6 units

Device and circuit level optimization of digital building blocks. MOS device models including Deep Sub-Micron effects. 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. Testing of integrated circuits. Extensive custom and standard cell layout and simulation in design projects and software labs.

*V. Sze, A. P. Chandrakasan***6.375 Complex Digital Systems Design**

Prereq: 6.004

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

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***Probabilistic Systems and Communication****6.401 Introduction to Statistical Data Analysis (New)**

Subject meets with 6.481

Prereq: 6.0001 and (6.008, 6.041, 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***6.402 Modeling with Machine Learning: from Algorithms to Applications (New)**

Subject meets with 6.482

Prereq: Calculus II (GIR) and 6.0001

U (Spring)

3-0-9 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. Recommended prerequisites include 6.006 and 18.06 or equivalent. Enrollment may be limited.

R. Barzilay, T. Jaakkola

6.419[J] Statistics, Computation and Applications

Same subject as IDS.012[J]

Subject meets with 6.439[J], IDS.131[J]

Prereq: ((2.087, 6.0002, 6.01, 18.03, or 18.06) and (6.008, 6.041, 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, S. Jegelka

6.431 Introduction to Probability

Subject meets with 6.041

Prereq: Calculus II (GIR)

G (Fall, Spring)

4-0-8 units

Credit cannot also be received for 15.079, 15.0791, 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

6.434[J] Statistics for Engineers and Scientists

Same subject as 16.391[J]

Prereq: Calculus II (GIR), 6.431, 18.06, or permission of instructor

G (Fall)

3-0-9 units

Rigorous introduction to fundamentals of statistics motivated by engineering applications. Topics include exponential families, order statistics, sufficient statistics, estimation theory, hypothesis testing, measures of performance, notions of optimality, analysis of variance (ANOVA), simple linear regression, and selected topics.

M. Win, J. N. Tsitsiklis

6.435 Bayesian Modeling and Inference

Prereq: 6.436[J] and 6.867

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

6.436[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.

J. N. Tsitsiklis, D. Gamarnik

6.437 Inference and Information

Prereq: 6.008, 6.041B, or 6.436[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 algorithm. 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

6.438 Algorithms for Inference

Prereq: 18.06 and (6.008, 6.041B, or 6.436[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***6.439[J] Statistics, Computation and Applications**

Same subject as IDS.131[J]

Subject meets with 6.419[J], IDS.012[J]

Prereq: ((2.087, 6.0002, 6.01, 18.03, or 18.06) and (6.008, 6.041, 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, S. Jegelka***6.440 Essential Coding Theory**

Prereq: 6.006 and 6.045[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***6.441 Information Theory**

Prereq: 6.041B

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

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***6.442 Optical Networks**

Prereq: 6.041B or 6.042[J]

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

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***6.443[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

6.450 Principles of Digital Communication

Prereq: 6.011

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Fall)

3-0-9 units

Communication sources and channels; data compression; entropy and the AEP; Lempel-Ziv universal coding; scalar and vector quantization; L2 waveforms; signal space and its representation by sampling and other expansions; aliasing; the Nyquist criterion; PAM and QAM modulation; Gaussian noise and random processes; detection and optimal receivers; fading channels and wireless communication; introduction to communication system design. Prior coursework in basic probability and linear system theory recommended.

V. W. S. Chan

6.452 Principles of Wireless Communication

Prereq: 6.450

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Fall)

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

6.454 Graduate Seminar in Area I

Prereq: Permission of instructor

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Fall)

2-0-4 units

Can be repeated for credit.

Student-run advanced graduate seminar with focus on topics in communications, control, signal processing, optimization. Participants give presentations outside of their own research to expose colleagues to topics not covered in the usual curriculum. Recent topics have included compressed sensing, MDL principle, communication complexity, linear programming decoding, biology in EECS, distributed hypothesis testing, algorithms for random satisfaction problems, and cryptography. Open to advanced students from all areas of EECS. Limited to 12.

L. Zheng, D. Shah

6.456 Array Processing

Prereq: 6.341 and (2.687 or (6.011 and 18.06))

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Fall)

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.

E. Fischell

6.481 Introduction to Statistical Data Analysis (New)

Subject meets with 6.401

Prereq: 6.0001 and (6.008, 6.041, 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

6.482 Modeling with Machine Learning: from Algorithms to Applications (New)

Subject meets with 6.402

Prereq: Calculus II (GIR) and 6.0001

G (Spring)

3-0-9 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. Recommended prerequisites include 6.006 and 18.06 or equivalent. Enrollment may be limited.

R. Barzilay, T. Jaakkola

Bioelectrical Engineering**6.521[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], 6.021[J], 9.21[J], 20.370[J]

Prereq: (Physics II (GIR), 18.03, and (2.005, 6.002, 6.003, 10.301, or 20.110[J])) or permission of instructor

G (Fall)

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. In person not required.

J. Han, T. Heldt

6.522[J] Quantitative Physiology: Organ Transport Systems

Same subject as 2.796[J]

Subject meets with 2.792[J], 6.022[J], HST.542[J]

Prereq: 6.021[J] and (2.006 or 6.013)

G (Spring)

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

6.524[J] Molecular, Cellular, and Tissue Biomechanics

Same subject as 2.798[J], 3.971[J], 10.537[J], 20.410[J]

Prereq: Biology (GIR) and (2.002, 2.006, 6.013, 10.301, or 10.302)

G (Fall, Spring)

3-0-9 units

See description under subject 20.410[J].

R. D. Kamm, K. J. Van Vliet

6.525[J] Medical Device Design

Same subject as 2.75[J], HST.552[J]

Subject meets with 2.750[J], 6.025[J]

Prereq: 2.008, 6.101, 6.111, 6.115, 22.071, or permission of instructor

G (Fall)

3-0-9 units

See description under subject 2.75[J]. Enrollment limited.

A. H. Slocum, G. Hom, E. Roche, N. C. Hanumara

6.542[J] Laboratory on the Physiology, Acoustics, and Perception of Speech

Same subject as 24.966[J], HST.712[J]

Prereq: Permission of instructor

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

2-2-8 units

Experimental investigations of speech processes. Topics include waveform analysis and spectral analysis of speech; synthesis of speech; perception and discrimination of speech-like sounds; speech prosody; models of speech recognition; speech development; analysis of atypical speech; and others. Recommended prerequisite: 6.002, 18.03, or 24.900.

S. Shattuck-Hufnagel, J.-Y. Choi

6.544, 6.545 Advanced Topics in BioEECS

Prereq: Permission of instructor

G (Fall, Spring)

Not offered regularly; consult department

3-0-9 units

Can be repeated for credit.

Advanced study of topics in BioEECS. Specific focus varies from year to year. Consult department for details.

Consult Department

6.552[J] Signal Processing by the Auditory System: Perception

Same subject as HST.716[J]

Prereq: (6.003 and (6.041B or 6.431)) or permission of instructor

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Fall)

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 tonotopic 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

6.555[J] Biomedical Signal and Image Processing

Same subject as 16.456[J], HST.582[J]

Subject meets with 6.026[J], HST.482[J]

Prereq: (6.041 and (2.004, 6.003, 16.002, or 18.085)) or permission of instructor

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

3-1-8 units

See description under subject HST.582[J].

J. Greenberg, E. Adalsteinsson, W. Wells

6.556[J] Data Acquisition and Image Reconstruction in MRI

Same subject as HST.580[J]

Prereq: 6.011

Acad Year 2020-2021: G (Fall)

Acad Year 2021-2022: 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

6.557[J] Biomolecular Feedback Systems

Same subject as 2.18[J]

Subject meets with 2.180[J], 6.027[J]

Prereq: Biology (GIR), 18.03, or permission of instructor

G (Spring)

3-0-9 units

See description under subject 2.18[J].

D. Del Vecchio, R. Weiss

6.561[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

6.580[J] Principles of Synthetic Biology

Same subject as 20.305[J]

Subject meets with 6.589[J], 20.405[J]

Prereq: None

U (Fall)

3-0-9 units

See description under subject 20.305[J].

R. Weiss

6.589[J] Principles of Synthetic Biology

Same subject as 20.405[J]

Subject meets with 6.580[J], 20.305[J]

Prereq: None

G (Fall)

3-0-9 units

See description under subject 20.405[J].

R. Weiss

Electrodynamics**6.602 Fundamentals of Photonics**

Subject meets with 6.621

Prereq: 2.71, 6.013, or 8.07

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

6.621 Fundamentals of Photonics

Subject meets with 6.602

Prereq: 2.71, 6.013, or 8.07

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

6.630 Electromagnetics

Prereq: Physics II (GIR) and 6.003

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.

M. R. Watts

6.631 Optics and Photonics

Prereq: 6.013 or 8.07

G (Fall)

3-0-9 units

Introduction to fundamental concepts and techniques of optics, photonics, and fiber optics. Review of Maxwell's equations, light propagation, and reflection from dielectrics mirrors and filters. Interferometers, filters, and optical imaging systems. Fresnel and Fraunhofer diffraction theory. Propagation of Gaussian beams and laser resonator design. Optical waveguides and optical fibers. Optical waveguide and photonic devices.

J. G. Fujimoto

6.632 Electromagnetic Wave Theory

Prereq: 6.013, 6.630, or 8.07

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

3-0-9 units

Solutions to Maxwell equations and physical interpretation. Topics include waves in media, equivalence principle, duality and complementarity, Huygens' principle, Fresnel and Fraunhofer diffraction, radiation and dyadic Green's functions, scattering, metamaterials, and plasmonics, mode theory, dielectric waveguides, and resonators. Examples deal with limiting cases of electromagnetic theory, multi-port elements, filters and antennas. Discusses current topics in microwave and photonic devices.

M. R. Watts

6.634[J] Nonlinear Optics

Same subject as 8.431[J]

Prereq: 6.013 or 8.07

G (Spring)

3-0-9 units

Techniques of nonlinear optics with emphasis on fundamentals for research and engineering in optics, photonics, and spectroscopy. Electro optic modulators, harmonic generation, and frequency conversion devices. Nonlinear effects in optical fibers including self-phase modulation, nonlinear wave propagation, and solitons. Interaction of light with matter, laser operation, density matrix techniques, nonlinear spectroscopies, and femtosecond optics.

*J. G. Fujimoto***6.637 Optical Imaging Devices, and Systems**

Prereq: 6.003

G (Fall)

3-0-9 units

Credit cannot also be received for 6.161

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***6.640 Electromagnetic Fields, Forces and Motion**

Subject meets with 6.014

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. L. Kirtley, Jr., J. H. Lang***6.644, 6.645 Advanced Topics in Applied Physics**

Prereq: Permission of instructor

G (Spring)

3-0-9 units

Can be repeated for credit.

Advanced study of topics in applied physics. Specific focus varies from year to year. Consult department for details.

*Consult Department***6.685 Electric Machines**

Prereq: (6.061 or 6.690) or permission of instructor

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Fall)

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.

6.690 Introduction to Electric Power Systems

Subject meets with 6.061

Prereq: 6.002 and 6.013

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

3-0-9 units

Electric circuit theory with application to power handling electric circuits. Modeling and behavior of electromechanical devices, including magnetic circuits, motors, and generators. Operational fundamentals of synchronous. Interconnection of generators and motors with electric power transmission and distribution circuits. Power generation, including alternative and sustainable sources. Incorporation of energy storage in power systems. Students taking graduate version complete additional assignments.

J. L. Kirtley, Jr.

6.695[J] Engineering, Economics and Regulation of the Electric Power Sector

Same subject as 15.032[J], IDS.505[J]

Subject meets with IDS.064

Prereq: 14.01, 22.081[J], IDS.060[J], or permission of instructor

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

3-0-9 units

See description under subject IDS.505[J].

I. Perez-Arriaga

Solid-State Materials and Devices**6.701 Introduction to Nanoelectronics**

Subject meets with 6.719

Prereq: 6.003

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

6.717[J] Design and Fabrication of Microelectromechanical Systems

Same subject as 2.374[J]

Subject meets with 2.372[J], 6.777[J]

Prereq: (Physics II (GIR) and (2.003[J] or 6.003)) or permission of instructor

U (Spring)

Not offered regularly; consult department

3-0-9 units

Provides an introduction to microsystem design. Covers material properties, microfabrication technologies, structural behavior, sensing methods, electromechanical actuation, thermal actuation and control, multi-domain modeling, noise, and microsystem packaging. Applies microsystem modeling, and manufacturing principles to the design and analysis a variety of microscale sensors and actuators (e.g., optical MEMS, bioMEMS, and inertial sensors). Emphasizes modeling and simulation in the design process. Students taking the graduate version complete additional assignments.

Staff

6.719 Nanoelectronics

Subject meets with 6.701

Prereq: 6.003

G (Fall)

Not offered regularly; consult department

4-0-8 units

Meets with undergraduate subject 6.701, but requires the completion of additional/different homework assignments and or projects. See subject description under 6.701.

M. A. Baldo

6.720[J] Integrated Microelectronic Devices

Same subject as 3.43[J]

Prereq: 3.42 or 6.012

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

6.728 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, thermionic emitters, atomic force microscope, and more. Some familiarity with continuous time Fourier transforms recommended.

*P. L. Hagelstein***6.730 Physics for Solid-State Applications**

Prereq: 6.013 and 6.728

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***6.731 Semiconductor Optoelectronics: Theory and Design**

Prereq: 6.012 and 6.728

Acad Year 2020-2021: G (Spring)

Acad Year 2021-2022: 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***6.732 Physics of Solids**

Prereq: 6.730 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***6.735, 6.736 Advanced Topics in Materials, Devices, and Nanotechnology**

Prereq: Permission of instructor

G (Fall, Spring)

Not offered regularly; consult department

3-0-9 units

Can be repeated for credit.

Advanced study of topics in materials, devices, and nanotechnology. Specific focus varies from year to year.

*Consult Department***6.774 Physics of Microfabrication: Front End Processing**

Prereq: 6.152[J]

G (Fall)

Not offered regularly; consult department

3-0-9 units

Presents advanced physical models and practical aspects of front-end microfabrication processes, such as oxidation, diffusion, ion implantation, chemical vapor deposition, atomic layer deposition, etching, and epitaxy. Covers topics relevant to CMOS, bipolar, and optoelectronic device fabrication, including high k gate dielectrics, gate etching, implant-damage enhanced diffusion, advanced metrology, stress effects on oxidation, non-planar and nanowire device fabrication, SiGe and fabrication of process-induced strained Si. Exposure to CMOS process integration concepts, and impacts of processing on device characteristics. Students use modern process simulation tools.

J. L. Hoyt, L. R. Reif

6.775 CMOS Analog and Mixed-Signal Circuit Design

Prereq: 6.301

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***6.776 High Speed Communication Circuits**

Prereq: 6.301

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***6.777[J] Design and Fabrication of Microelectromechanical Systems**

Same subject as 2.372[J]

Subject meets with 2.374[J], 6.717[J]

Prereq: (Physics II (GIR) and (2.003[J] or 6.003)) or permission of instructor

G (Spring)

Not offered regularly; consult department

3-0-9 units

Provides an introduction to microsystem design. Covers material properties, microfabrication technologies, structural behavior, sensing methods, electromechanical actuation, thermal actuation and control, multi-domain modeling, noise, and microsystem packaging. Applies microsystem modeling, and manufacturing principles to the design and analysis a variety of microscale sensors and actuators (e.g., optical MEMS, bioMEMS, and inertial sensors). Emphasizes modeling and simulation in the design process. Students taking the graduate version complete additional assignments.

*Staff***6.780[J] Control of Manufacturing Processes**

Same subject as 2.830[J]

Prereq: 2.008, 6.041, or 6.152[J]

G (Fall)

3-0-9 units

See description under subject 2.830[J].

*D. E. Hardt, D. S. Boning***6.781[J] Nanostructure Fabrication**

Same subject as 2.391[J]

Prereq: (2.710, 6.152[J], or 6.161) or permission of instructor

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: 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***Computer Science****6.801 Machine Vision**

Subject meets with 6.866

Prereq: 6.003 or permission of instructor

Acad Year 2020-2021: U (Fall)

Acad Year 2021-2022: Not offered

3-0-9 units

Deriving a symbolic description of the environment from an image. Understanding physics of image formation. Image analysis as an inversion problem. Binary image processing and filtering of images as preprocessing steps. Recovering shape, lightness, orientation, and motion. Using constraints to reduce the ambiguity. Photometric stereo and extended Gaussian sphere. Applications to robotics; intelligent interaction of machines with their environment. Students taking the graduate version complete different assignments.

B. K. P. Horn

6.802[J] Computational Systems Biology: Deep Learning in the Life Sciences

Same subject as 20.390[J]

Subject meets with 6.874[J], 20.490, HST.506[J]

Prereq: (7.05 and (6.0002 or 6.01)) or permission of instructor

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

6.803 The Human Intelligence Enterprise

Subject meets with 6.833

Prereq: 6.034 or permission of instructor

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: U (Spring)

3-0-9 units

Analyzes seminal work directed at the development of a computational understanding of human intelligence, such as work on learning, language, vision, event representation, commonsense reasoning, self reflection, story understanding, and analogy. Reviews visionary ideas of Turing, Minsky, and other influential thinkers. Examines the implications of work on brain scanning, developmental psychology, and cognitive psychology. Emphasis on discussion and analysis of original papers. Students taking graduate version complete additional assignments. Enrollment limited.

P. H. Winston

6.804[J] Computational Cognitive Science

Same subject as 9.66[J]

Subject meets with 9.660

Prereq: 6.008, 6.036, 6.041, 9.40, 18.05, or permission of instructor

U (Fall)

3-0-9 units

See description under subject 9.66[J].

J. Tenenbaum

6.805[J] Foundations of Information Policy

Same subject as STS.085[J]

Subject meets with STS.487

Prereq: Permission of instructor

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

6.806 Advanced Natural Language Processing

Subject meets with 6.864

Prereq: 6.046[J] or permission of instructor

U (Spring)

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, and summarization. Students taking graduate version complete additional assignments.

R. A. Barzilay

6.807 Computational Design and Fabrication

Prereq: Calculus II (GIR) and (6.009 or permission of instructor)

U (Fall)

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.

W. Matusik

6.808[J] Mobile and Sensor Computing

Same subject as MAS.453[J]

Prereq: 6.033 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

6.809[J] Interactive Music Systems

Same subject as 21M.385[J]

Prereq: (6.009 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 18.

E. Egozy, L. Kaelbling

6.810 Engineering Interactive Technologies

Prereq: 6.031, 6.08, 6.111, 6.115, or permission of instructor

U (Fall)

3-3-6 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

6.811[J] Principles and Practice of Assistive Technology

Same subject as 2.78[J], HST.420[J]

Prereq: Permission of instructor

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: U (Fall)

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

6.812 Hardware Architecture for Deep Learning

Subject meets with 6.825

Prereq: 6.003 or 6.004

U (Spring)

3-3-6 units

Introduction to the design and implementation of hardware architectures for efficient processing of deep learning algorithms in AI systems. Topics include basics of deep learning, programmable platforms, accelerators, co-optimization of algorithms and hardware, training, support for complex networks, and applications of advanced technologies. Includes labs involving modeling and analysis of hardware architectures, building systems using popular deep learning tools and platforms (CPU, GPU, FPGA), and an open-ended design project. Students taking graduate version complete additional assignments.

V. Sze, J. Emer

6.814 Database Systems

Subject meets with 6.830

Prereq: (6.033 and (6.006 or 6.046[JJ])) or permission of instructor
U (Spring)

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

6.815 Digital and Computational Photography

Subject meets with 6.865

Prereq: Calculus II (GIR) and 6.009
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

6.816 Multicore Programming

Subject meets with 6.836

Prereq: 6.006
U (Fall)

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

6.817[JJ] Principles of Autonomy and Decision Making

Same subject as 16.410[JJ]

Subject meets with 6.877[JJ], 16.413[JJ]

Prereq: 6.0002 or 6.01

U (Fall)

4-0-8 units

See description under subject 16.410[JJ].

H. E. Shrobe

6.818 Dynamic Computer Language Engineering

Prereq: 6.004 or 6.031

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

6.819 Advances in Computer Vision

Subject meets with 6.869

Prereq: 18.06 and (6.041B or 6.042[JJ])

U (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 6.801. Students taking graduate version complete additional assignments.

W. T. Freeman, A. Torralba

6.820 Foundations of Program Analysis

Prereq: 6.035

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: 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

6.822 Formal Reasoning About Programs

Prereq: 6.031 and 6.042[J]

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***6.823 Computer System Architecture**

Prereq: 6.004

G (Spring)

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***6.824 Distributed Computer Systems Engineering**

Prereq: 6.033 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***6.825 Hardware Architecture for Deep Learning**

Subject meets with 6.812

Prereq: 6.003 or 6.004

G (Spring)

3-3-6 units

Introduction to the design and implementation of hardware architectures for efficient processing of deep learning algorithms in AI systems. Topics include basics of deep learning, programmable platforms, accelerators, co-optimization of algorithms and hardware, training, support for complex networks, and applications of advanced technologies. Includes labs involving modeling and analysis of hardware architectures, building systems using popular deep learning tools and platforms (CPU, GPU, FPGA), and an open-ended design project. Students taking graduate version complete additional assignments.

*V. Sze, J. Emer***6.826 Principles of Computer Systems**

Prereq: Permission of instructor

G (Fall)

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***6.828 Operating System Engineering**

Prereq: 6.031 and 6.033

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

6.829 Computer Networks

Prereq: 6.033 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

6.830 Database Systems

Subject meets with 6.814

Prereq: (6.033 and (6.006 or 6.046[JJ])) or permission of instructor

G (Spring)

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

6.832 Underactuated Robotics

Prereq: 2.12, 2.165[JJ], 6.141[JJ], or permission of instructor

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

6.833 The Human Intelligence Enterprise

Subject meets with 6.803

Prereq: 6.034

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

3-0-9 units

Analyzes seminal work directed at the development of a computational understanding of human intelligence, such as work on learning, language, vision, event representation, commonsense reasoning, self reflection, story understanding, and analogy. Reviews visionary ideas of Turing, Minsky, and other influential thinkers. Examines the implications of work on brain scanning, developmental psychology, and cognitive psychology. Emphasis on discussion and analysis of original papers. Requires the completion of additional exercises and a substantial term project. Enrollment limited.

P. H. Winston

6.834[JJ] Cognitive Robotics

Same subject as 16.412[JJ]

Prereq: (6.034 or 16.413[JJ]) and (6.042[JJ], 16.09, or 6.041)

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

3-0-9 units

See description under subject 16.412[JJ]. Enrollment may be limited.

B. C. Williams

6.835 Intelligent Multimodal User Interfaces

Prereq: 6.031, 6.034, 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

6.836 Multicore Programming

Subject meets with 6.816

Prereq: 6.006

G (Fall)

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

6.837 Computer Graphics

Prereq: (Calculus II (GIR) and 6.031) or permission of instructor
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

6.838 Shape Analysis

Prereq: Calculus II (GIR), 18.06, and (6.837 or 6.869)

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

6.839 Advanced Computer Graphics

Prereq: 6.031, 6.837, 18.06, or permission of instructor

G (Fall)

3-0-9 units

A graduate level course investigates computational problems in rendering, animation, and geometric modeling. The course draws on advanced techniques from computational geometry, applied mathematics, statistics, scientific computing and other. Substantial programming experience required.

W. Matusik

6.840[J] Theory of Computation

Same subject as 18.4041[J]

Subject meets with 18.404

Prereq: 6.042[J] or 18.200

G (Fall)

4-0-8 units

See description under subject 18.4041[J].

M. Sipser

6.841[J] Advanced Complexity Theory

Same subject as 18.405[J]

Prereq: 18.404

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Fall)

3-0-9 units

See description under subject 18.405[J].

R. Williams

6.842 Randomness and Computation

Prereq: 6.046[J] and 18.4041[J]

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: 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

6.844 Artificial Intelligence

Prereq: 6.0001

G (Fall)

4-3-5 units

Credit cannot also be received for 6.034

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***6.845 Quantum Complexity Theory**

Prereq: 6.045[[]], 18.4041[[]], and 18.435[[]]

G (Fall)

Not offered regularly; consult department

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***6.846 Parallel Computing**

Prereq: 6.004 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***6.849 Geometric Folding Algorithms: Linkages, Origami, Polyhedra**

Prereq: 6.046[[]] or permission of instructor

Acad Year 2020-2021: G (Fall)

Acad Year 2021-2022: Not offered

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***6.850 Geometric Computing**

Prereq: 6.046[[]]

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

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

6.851 Advanced Data Structures

Prereq: 6.046[J]

Acad Year 2020-2021: G (Spring)

Acad Year 2021-2022: 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***6.852[J] Distributed Algorithms**

Same subject as 18.437[J]

Prereq: 6.046[J]

Acad Year 2020-2021: G (Fall)

Acad Year 2021-2022: Not offered

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.

*N. A. Lynch***6.853 Topics in Algorithmic Game Theory**

Prereq: 6.006 or 6.046[J]

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: 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***6.854[J] Advanced Algorithms**

Same subject as 18.415[J]

Prereq: 6.046[J] and (6.042[J], 18.600, or 6.041)

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***6.855 Sublinear Time Algorithms (New)**

Prereq: 6.046[J] or permission of instructor

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

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

6.856[J] Randomized Algorithms

Same subject as 18.416[J]

Prereq: (6.041 or 6.042[J]) and (6.046[J] or 6.854[J])

Acad Year 2020-2021: G (Spring)

Acad Year 2021-2022: 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***6.857 Network and Computer Security**

Prereq: 6.033 and 6.042[J]

G (Spring)

4-0-8 units

Emphasis on applied cryptography and may include: basic notion of systems security, cryptographic hash functions, symmetric cryptography (one-time pad, stream ciphers, block ciphers), cryptanalysis, secret-sharing, authentication codes, public-key cryptography (encryption, digital signatures), public-key attacks, elliptic curve cryptography; pairing functions, fully homomorphic encryption, differential privacy, bitcoin, viruses, electronic voting. Assignments include a group final project. Topics may vary year to year.

*R. L. Rivest, Y. Kalai,***6.858 Computer Systems Security**

Prereq: 6.031 and 6.033

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Fall)

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***6.859 Interactive Data Visualization (New)**

Prereq: 6.031

G (Spring)

3-0-9 units

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***6.860[J] Statistical Learning Theory and Applications**

Same subject as 9.520[J]

Prereq: 6.041, 6.867, 18.06, or permission of instructor

G (Fall)

3-0-9 units

See description under subject 9.520[J].

*T. Poggio, L. Rosasco***6.861[J] Aspects of a Computational Theory of Intelligence**

Same subject as 9.523[J]

Prereq: Permission of instructor

G (Fall)

Not offered regularly; consult department

3-0-9 units

See description under subject 9.523[J].

*T. Poggio, S. Ullman***6.862 Applied Machine Learning**

Prereq: Permission of instructor

G (Fall, Spring)

4-0-8 units

Credit cannot also be received for 6.036

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; classification, regression, reinforcement learning; and methods such as linear classifiers, feed-forward, convolutional, and recurrent networks. Students taking graduate version complete different assignments. Meets with 6.036 when offered concurrently. Recommended prerequisites: 18.06 and 6.006. Enrollment limited; no listeners.

S. Jegelka

6.863[*J*] Natural Language and the Computer Representation of Knowledge

Same subject as 9.611[*J*]

Prereq: 6.034

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: 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

6.864 Advanced Natural Language Processing

Subject meets with 6.806

Prereq: 6.046[*J*] or permission of instructor

G (Spring)

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, and summarization. Students taking graduate version complete additional assignments.

R. A. Barzilay

6.865 Advanced Computational Photography

Subject meets with 6.815

Prereq: Calculus II (GIR) and 6.031

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

6.866 Machine Vision

Subject meets with 6.801

Prereq: 6.003 or permission of instructor

Acad Year 2020-2021: G (Fall)

Acad Year 2021-2022: Not offered

3-0-9 units

Intensive introduction to the process of generating a symbolic description of the environment from an image. Students expected to attend the 6.801 lectures as well as occasional seminar meetings on special topics. Material presented in 6.801 is supplemented by reading from the literature. Students required to implement a project on a topic of their choice from the material covered.

B. K. P. Horn

6.867 Machine Learning

Prereq: 18.06 and (6.041B 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: 6.036 or other previous experience in machine learning. Enrollment may be limited.

D. Shah, D. Sontag, S. Sra

6.869 Advances in Computer Vision

Subject meets with 6.819

Prereq: 18.06 and (6.041B or 6.042[*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 6.866. Students taking graduate version complete additional assignments.

W. T. Freeman, A. Torralba

6.870 Advanced Topics in Computer Vision

Prereq: 6.801, 6.869, or permission of instructor

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Fall)

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

6.871[J] Machine Learning for Healthcare

Same subject as HST.956[J]

Prereq: 6.034, 6.036, 6.438, 6.806, 6.867, or 9.520[J]

G (Spring)

4-0-8 units

See description under subject HST.956[J]. Limited to 55.

D. Sontag, P. Szolovits

6.872[J] Biomedical Computing

Same subject as HST.950[J]

Prereq: 6.034, 6.036, or permission of instructor

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Fall)

3-0-9 units

Analyzes computational needs of clinical medicine, reviews systems and approaches that have been used to support those needs, and the relationship between clinical data and gene and protein measurements to support precision medicine. Topics include the nature of clinical data, architecture and design of healthcare information systems, privacy and security issues, medical expert systems, predictive models and machine learning from big data in healthcare, and an introduction to bioinformatics. Case studies and guest lectures describe contemporary institutions, systems, and research projects. Term project using large clinical and genomic data sets integrates classroom topics.

G. Alterovitz, P. Szolovits

6.874[J] Computational Systems Biology: Deep Learning in the Life Sciences

Same subject as HST.506[J]

Subject meets with 6.802[J], 20.390[J], 20.490

Prereq: Biology (GIR) and (18.600 or 6.041)

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: 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

6.875[J] Cryptography and Cryptanalysis

Same subject as 18.425[J]

Prereq: 6.046[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

6.876 Advanced Topics in Cryptography

Prereq: 6.875[J]

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

3-0-9 units

Can be repeated for credit.

In-depth exploration of recent results in cryptography.

S. Goldwasser, S. Micali, V. Vaikuntanathan

6.877[J] Principles of Autonomy and Decision Making

Same subject as 16.413[J]

Subject meets with 6.817[J], 16.410[J]

Prereq: 6.0002, 6.01, or permission of instructor

G (Fall)

3-0-9 units

See description under subject 16.413[J].

B. C. Williams

6.878[J] Advanced Computational Biology: Genomes, Networks, Evolution

Same subject as HST.507[J]

Subject meets with 6.047

Prereq: (Biology (GIR), 6.006, and 6.041) 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

6.881 Advanced Topics in Artificial Intelligence

Prereq: Permission of instructor

G (Fall, Spring)

3-0-9 units

Can be repeated for credit.

Advanced study of topics in artificial intelligence. Specific focus varies from year to year. Consult department for details.

Consult Department

6.882 Advanced Topics in Artificial Intelligence

Prereq: Permission of instructor

G (Fall)

3-0-9 units

Can be repeated for credit.

Advanced study of topics in artificial intelligence. Specific focus varies from year to year. Consult department for details.

Consult Department

6.883 Advanced Topics in Artificial Intelligence

Prereq: Permission of instructor

G (Fall)

3-0-9 units

Can be repeated for credit.

Advanced study of topics in artificial intelligence. Specific focus varies from year to year. Consult department for details.

Consult Department

6.884 Advanced Topics in Artificial Intelligence

Prereq: Permission of instructor

G (Fall, Spring)

3-0-9 units

Can be repeated for credit.

Advanced study of topics in artificial intelligence. Specific focus varies from year to year. Consult department for details.

Consult Department

6.885 Advanced Topics in Computer Systems

Prereq: Permission of instructor

G (Spring)

Not offered regularly; consult department

3-0-9 units

Can be repeated for credit.

Advanced study of topics in computer systems. Specific focus varies from year to year. Consult department for details.

Consult Department

6.886 Advanced Topics in Computer Systems

Prereq: Permission of instructor

G (Spring)

3-0-9 units

Can be repeated for credit.

Advanced study of topics in computer systems. Specific focus varies from year to year. Consult department for details.

Consult Department

6.887 Advanced Topics in Computer Systems

Prereq: Permission of instructor

G (Spring)

Not offered regularly; consult department

3-0-9 units

Can be repeated for credit.

Advanced study of topics in computer systems. Specific focus varies from year to year. Consult department for details.

Consult Department

6.888 Advanced Topics in Computer Systems

Prereq: Permission of instructor

G (Fall)

3-0-9 units

Can be repeated for credit.

Advanced study of topics in computer systems. Specific focus varies from year to year. Consult department for details.

Consult Department

6.889 Advanced Topics in Theoretical Computer Science

Prereq: Permission of instructor

G (Fall)

3-0-9 units

Can be repeated for credit.

Advanced study of topics in theoretical computer science. Specific focus varies from year to year. Consult department for details.

Consult Department

6.890 Advanced Topics in Theoretical Computer Science

Prereq: Permission of instructor

G (Spring)

Not offered regularly; consult department

3-0-9 units

Can be repeated for credit.

Advanced study of topics in theoretical computer science. Specific focus varies from year to year. Consult department for details.

Consult Department

6.891 Advanced Topics in Theoretical Computer Science

Prereq: Permission of instructor

G (Fall, Spring)

Not offered regularly; consult department

3-0-9 units

Can be repeated for credit.

Advanced study of topics in theoretical computer science. Specific focus varies from year to year. Consult department for details.

Consult Department

6.892 Advanced Topics in Theoretical Computer Science

Prereq: Permission of instructor

G (Spring)

Not offered regularly; consult department

3-0-9 units

Can be repeated for credit.

Advanced study of topics in theoretical computer science. Specific focus varies from year to year. Consult department for details.

Consult Department

6.893 Advanced Topics in Theoretical Computer Science

Prereq: Permission of instructor

G (Fall)

3-0-9 units

Can be repeated for credit.

Advanced study of topics in theoretical computer science. Specific focus varies from year to year. Consult department for details.

Consult Department

6.894 Advanced Topics in Graphics and Human-Computer Interfaces

Prereq: Permission of instructor

G (Spring)

Not offered regularly; consult department

3-0-9 units

Can be repeated for credit.

Advanced study of topics in graphics and human-computer interfaces. Specific focus varies from year to year. Consult department for details.

Consult Department

6.895 Advanced Topics in Graphics and Human-Computer Interfaces

Prereq: Permission of instructor

G (Fall, Spring)

Not offered regularly; consult department

3-0-9 units

Can be repeated for credit.

Advanced study of topics in graphics and human-computer interfaces. Specific focus varies from year to year. Consult department for details.

Consult Department

6.896 Advanced Topics in Graphics and Human-Computer Interfaces

Prereq: Permission of instructor

G (Fall, Spring)

Not offered regularly; consult department

3-0-9 units

Can be repeated for credit.

Advanced study of topics in graphics and human-computer interfaces. Specific focus varies from year to year. Consult department for details.

Consult Department

6.897 Advanced Topics in Computer Graphics

Prereq: 6.837

G (Spring)

Not offered regularly; consult department

3-0-9 units

In-depth study of an active research topic in computer graphics. Topics change each term. Readings from the literature, student presentations, short assignments, and a programming project.

J. Solomon

6.901[J] Engineering Innovation: Moving Ideas to Impact

Same subject as 15.359[J]

Prereq: None

U (Fall)

3-3-6 units

See description under subject 15.359[J].

*V. Bulovic, F. Murray***6.902 Design Thinking and Innovation Leadership for Engineers**

Engineering School-Wide Elective Subject.

Offered under: 2.723, 6.902, 16.662

Prereq: None

U (Fall, Spring)

2-1-3 units

Project-based course develops students' ability to conceive, implement, and evaluate successful projects in any engineering discipline. Lessons focus on an iterative design process, 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, using a systems thinking approach for stakeholder analysis, and communicating solution concepts with impact. Working in teams, students employ design thinking techniques and leadership skills to collaboratively conceive, implement, and iteratively refine through user feedback robust applications using a simple web-based platform. Students also give oral presentations and receive feedback to sharpen their communication skills.

*B. Kotelly***6.9021[J] Introduction to Design Thinking and Innovation in Engineering (New)**

Same subject as 2.7231[J], 16.6621[J]

Prereq: None

U (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 9-unit discovery-focused credit limit for first-year students. Enrollment limited to 25; priority to first-year students.

*B. Kotelly***6.903 Patents, Copyrights, and the Law of Intellectual Property**

Prereq: None

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: U (Fall)

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***6.904 Ethics for Engineers**

Engineering School-Wide Elective Subject.

Offered under: 1.082, 2.900, 6.904, 10.01, 16.676, 22.014

Subject meets with 6.9041, 20.005

Prereq: None

U (Fall, Spring)

2-0-4 units

See description under subject 10.01. Limited to 18 per section.

*D. A. Lauffenberger, B.L. Trout***6.9041 Ethics for Engineers - Independent Inquiry**

Subject meets with 1.082[J], 2.900[J], 6.904[J], 10.01[J], 16.676[J], 20.005, 22.014[J]

Prereq: None

U (Fall, Spring)

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. In person not required. Limited to 18 per section.

D. A. Lauffenberger, B. L. Trout

6.905 Large-scale Symbolic Systems

Subject meets with 6.945

Prereq: 6.034 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

6.906 StartMIT: Workshop for Entrepreneurs and Innovators

Subject meets with 6.936

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

6.910 Independent Study in Electrical Engineering and Computer Science

Prereq: Permission of instructor

U (Fall, IAP, Spring, Summer)

Units arranged

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

6.911 Engineering Leadership Lab

Engineering School-Wide Elective Subject.

Offered under: 6.911, 16.650

Subject meets with 6.913[], 16.667[]

Prereq: None. *Coreq:* 6.912; or permission of instructor

U (Fall, Spring)

0-2-1 units

Can be repeated for credit.

Develops leadership, teamwork and communication skills by exposing students to leadership frameworks, models, and cases within an engineering context in an interactive, practice-based environment. Students are members of and lead teams, participate in guided reflections on individual and team successes, and discover opportunities for improvement in controlled settings. Experiential learning includes design-implement activities, role-play simulations, small group discussions, and performance and peer assessments by and of other students. Includes frequent engineering industry-guest participation. Content is frequently student-driven. First year Gordon Engineering Leadership Program (GEL) students register for 6.911. Second year GEL Program students register for 6.913. Preference to students enrolled in the Bernard M. Gordon-MIT Engineering Leadership Program.

L. McGonagle, J. Feiler

6.912 Engineering Leadership

Engineering School-Wide Elective Subject.

Offered under: 6.912, 16.651

Prereq: None. *Coreq:* 6.911; 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

6.913 Engineering Leadership Lab

Engineering School-Wide Elective Subject.

Offered under: 6.913, 16.667

Subject meets with 6.911[J], 16.650[J]

Prereq: 6.902, 6.911, 6.912, 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

6.914 Project Engineering

Engineering School-Wide Elective Subject.

Offered under: 6.914, 16.669

Prereq: (6.902 and (6.911 or 6.912)) 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

6.915[J] Leading Innovation in Teams

Same subject as 16.671[J]

Prereq: None

U (Spring)

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

6.920 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

6.921 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

6.922 Advanced 6-A Internship

Prereq: 6.921

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

6.928[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

6.929[J] Energy Technology and Policy: From Principles to Practice

Same subject as 5.00[J], 10.579[J], 22.813[J]

Prereq: None

G (Fall; first half of term)

Not offered regularly; consult department

3-0-6 units

Develops analytical skills to lead a successful technology implementation with an integrated approach that combines technical, economical and social perspectives. Considers corporate and government viewpoints as well as international aspects, such as nuclear weapons proliferation and global climate issues. Discusses technologies such as oil and gas, nuclear, solar, and energy efficiency. Limited to 100.

J. Deutch

6.930 Management in Engineering

Engineering School-Wide Elective Subject.

Offered under: 2.96, 6.930, 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

6.934[J] Engineering, Economics and Regulation for Energy Access in Developing Countries

Same subject as 15.017[J]

Prereq: None

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

3-0-9 units

See description under subject 15.017[J].

I. Perez-Arriaga, R. Stoner

6.935[J] Financial Market Dynamics and Human Behavior

Same subject as 15.481[J]

Prereq: 15.401, 15.414, or 15.415

Acad Year 2020-2021: Not offered

Acad Year 2021-2022: G (Spring)

4-0-5 units

See description under subject 15.481[J].

A. Lo

6.936 StartMIT: Workshop for Entrepreneurs and Innovators

Subject meets with 6.906

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.

A. Chandrakasan

6.941 Statistics for Research Projects: Statistical Modeling and Experiment Design

Prereq: None

G (IAP)

Not offered regularly; consult department

2-2-2 units

Practical introduction to data analysis, statistical modeling, and experimental design, intended to provide essential skills for conducting research. Covers basic techniques such as hypothesis-testing and regression models for both traditional experiments and newer paradigms such as evaluating simulations. Assignments reinforce techniques through analyzing sample datasets and reading case studies. Students with research projects will be encouraged to share their experiences and project-specific questions.

*Staff***6.943[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. Lavalley, G. Darcey***6.945 Large-scale Symbolic Systems**

Subject meets with 6.905

Prereq: 6.034 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***6.946[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***6.951 Graduate 6-A Internship**

Prereq: 6.921 or 6.922

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***6.952 Graduate 6-A Internship**

Prereq: 6.951

G (Fall, Spring, Summer)

0-12-0 units

Provides academic credit for graduate students who require an additional term at the company to complete the graduate assignment of the department's 6-A internship program. This academic credit is for registration purposes only and cannot be used toward fulfilling the requirements of any degree program. Limited to graduate students participating in the 6-A internship program.

*T. Palacios***6.960 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. Kolodziejwski

6.961 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. Kolodziejcki

6.962 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. Kolodziejcki

6.963 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

6.980 Teaching Electrical Engineering and Computer Science

Prereq: None
G (Fall, Spring)
Units arranged [P/D/F]
Can be repeated for credit.

For qualified students interested in gaining teaching experience. Classroom, tutorial, or laboratory teaching under the supervision of a faculty member. Enrollment limited by availability of suitable teaching assignments.

H. S. Lee, R. C. Miller

6.981 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.

H. S. Lee, R. C. Miller

6.991 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

6.994 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

6.995 Professional Perspective II

Prereq: 6.994

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

6.997 Professional Perspective Internship

Prereq: None

G (Fall, IAP, Spring, Summer)

0-1-0 units

Required for Course 6 students in the MEng program to gain professional perspective in research experiences or internships in electrical engineering or computer science. Before enrolling, students must have an offer of employment from a company or organization. Employers must document the work accomplished. Written report required upon completion of a minimum of four weeks of off-campus experience. Proposals subject to departmental approval. For international students who begin the MEng program in the same summer as the proposed experience, internship may not begin earlier than the first day of the Summer Session.

Consult Department Undergraduate Office

6.998 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.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: 2.EPW or permission of instructor

U (Fall, Spring)

0-0-1 units

See description under subject 2.EPE.

Staff

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: None

U (Fall, IAP)

1-0-0 units

See description under subject 2.EPW. Enrollment limited.

Staff

6.S897 Special Subject in Computer Science

Prereq: Permission of instructor

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.S898 Special Subject in Computer Science

Prereq: Permission of instructor

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.S899 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.S911 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

6.S912 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.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.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; second half of term)

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 (Spring; first half of term)

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 (Spring; first half of term)

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 (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.S978 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.S979 Special Subject in Electrical Engineering and Computer Science

Prereq: Permission of instructor

G (Fall, 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.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.

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6.THM Master of Engineering Program Thesis

Prereq: 6.UAT

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