ELECTRICAL ENGINEERING AND COMPUTER SCIENCE (COURSE 6)

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

6.002 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 Signals and Systems
Prereq: Calculus I (GIR) and (6.0001 or 6.145)
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.
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 or 6.145
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.
*D. S. Boning, A. Chipala, S. Devadas, A. Hartz*

6.01 Introduction to EECS via Robotics
Prereq: 6.001, 6.145, or permission of instructor
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: 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 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. Labs 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.
*L. Daniel, M. R. Watts*
6.014 Electromagnetic Fields, Forces and Motion
Subject meets with 6.640
Prereq: Physics II (GIR) and 18.03
U (Fall)
3-0-9 units
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. 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: Physics II (GIR) and (2.005, 6.021[J]), or permission of instructor; Coreq: 20.309[J]
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)  
U (Spring)  
3-3-6 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  
Subject meets with 6.844  
Prereq: 6.0001  
U (Fall)  
4-3-5 units  
Introduces representations, methods, and architectures used to build applications and to account for human intelligence from a computational point of view. Covers applications of rule chaining, constraint propagation, constrained search, inheritance, statistical inference, and other problem-solving paradigms. Also addresses applications of identification trees, neural nets, genetic algorithms, support-vector machines, boosting, and other learning paradigms. Considers what separates human intelligence from that of other animals. Students taking graduate version complete additional assignments.  
_P. H. Winston_  

6.035 Computer Language Engineering  
Prereq: 6.004 and 6.031  
U (Fall)  
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.  
_R. Barzilay, T. Jaakkola, L. P. Kaelbling_  

6.037 Structure and Interpretation of Computer Programs  
Prereq: None  
U (IAP)  
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  
_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 computer science and engineering. Emphasis on mathematical definitions and proofs as well as on applicable methods. Topics include formal logic notation, proof methods; induction, well-ordering; sets, relations; elementary graph theory; asymptotic notation and growth of functions; permutations and combinations, counting principles; discrete probability. Further selected topics include recursive definition and structural induction, state machines and invariants, integer congruences, recurrences, generating functions.  
_F. T. Leighton, Z. R. Abel, A. Moitra_
6.045[J] Automata, Computability, and Complexity
Same subject as 18.400[J]
Prereq: 6.042[J]
U (Spring)
4-0-8 units
Mathematical introduction to questions concerning the definition
of computation, and what problems can be solved by computers.
Considers what problems can be efficiently solved by way of finite
automata, circuits, Turing machines, and communication complexity.
Provides complete, rigorous answers to the questions in some
cases; others are major open problems. Builds skills in classifying
computational problems in terms of their difficulty. Discusses other
fundamental issues, including 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 2019-2020: Not offered
Acad Year 2020-2021: U (Spring)
3-0-6 units
See description under subject 2.110[J].
S. Lloyd, P. Penfield, Jr.

6.057 Introduction to MATLAB
Prereq: None
U (IAP)
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)
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 2019-2020: Not offered
Acad Year 2020-2021: 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. Enrollment may be limited.
J. Bales

6.072[J] Introduction to Digital Electronics
Same subject as EC.110[J]
Prereq: None
U (Fall)
Not offered regularly; consult department
0-3-3 units
See description under subject EC.110[J]. Maximum of 10 students per term, lottery at the first class session if oversubscribed.
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

6.08 Introduction to EECS via Interconnected Embedded Systems
Prereq: 6.0001 or 6.145; 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. Enrollment limited; preference to first- and second-year students.
S. Mueller, J. D. Steinmeyer, J. Voldman

6.S062 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Spring)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.
Basic undergraduate subjects not offered in the regular curriculum.
Consult Department
6.063 Special Subject in Electrical Engineering and Computer Science
Prereq: None
U (Fall)
Units arranged
Can be repeated for credit.
Basic undergraduate subjects not offered in the regular curriculum.
Consult Department

6.076-6.084 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

6.085-6.099 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 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 light 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.
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)
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
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
Same subject as 20.129[J]
Prereq: Biology (GIR) and Calculus II (GIR)
U (Spring)
2-8-2 units. Institute LAB

Students assemble individual genes and regulatory elements into larger-scale circuits; they experimentally characterize these circuits in yeast cells using quantitative techniques, including flow cytometry, and model their results computationally. Emphasizes concepts and techniques to perform independent experimental and computational synthetic biology research. Discusses current literature and ongoing research in the field of synthetic biology. Instruction and practice in oral and written communication provided. Enrollment limited.
T. Lu, R. Weiss
6.131 Power Electronics Laboratory
Subject meets with 6.1311
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
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

6.145 Brief Introduction to Python
Prereq: None
U (IAP; partial term)
0-1-2 units
Three-week introduction to programming in Python for students with little or no prior experience, designed to be taken prior to 6.01 or 6.08. Provides instruction in the basics of programming in Python through online materials and in-class laboratory exercises.
A. Hartz

6.146 Mobile Autonomous Systems Laboratory: MASLAB
Prereq: None
U (IAP)
2-2-2 units
Can be repeated for credit.
Autonomous robotics contest emphasizing technical AI, vision, mapping and navigation from a robot-mounted camera. Few restrictions are placed on materials, sensors, and/or actuators enabling teams to build robots very creatively. Teams should have members with varying engineering, programming and mechanical backgrounds. Culminates with a robot competition at the end of IAP. Enrollment limited.
Staff

6.147 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.

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.

Same subject as 3.155[J]
Prereq: Calculus II (GIR), Chemistry (GIR), Physics II (GIR), or permission of instructor
U (Fall)
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
Subject meets with 6.637
Prereq: 6.003
U (Fall)
3-5-4 units. Institute LAB

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

C. Warde
6.163 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

6.169 Theory and Application of Circuits and Electronics
Prereq: None. Coreq: 6.002
U (Fall)
Not offered regularly; consult department
1-1-1 units
Building on the framework of 6.002, provides a deeper understanding of the theory and applications of circuits and electronics.
A. Agarwal, J. del Alamo, J. H. Lang, D. J. Perreault

6.170 Software Studio
Prereq: 6.031 and 6.042[J]
U (Fall)
4-9-2 units
Covers the design of software applications, with an emphasis on user experience. Provides instruction on how to craft robust and flexible implementations and how to shape the user experience through the design of interfaces and behavior. Topics include need finding, conceptual design, prototyping, data design and user interface design, as well as programming with JavaScript, a reactive front-end framework and a cloud data store. 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 2019-2020: Not offered
Acad Year 2020-2021: 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)
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)
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)
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
6.5187 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

6.5188 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

6.5189 Special Laboratory Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
U (IAP)
Units arranged [P/D/F]
Can be repeated for credit.
Laboratory subject that covers content not offered in the regular curriculum. Consult department to learn of offerings for a particular term.
D. M. Freeman

6.5191 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

6.5192 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

6.5197 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

6.5193-6.5198 Special Laboratory Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: U (Fall)
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.
*A. P. Chandrakasan, D. M. Freeman, D. Katabi*

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. Enrollment may be limited.
*T. L. Eng*

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

Year-long individual research project arranged with appropriate faculty member or approved supervisor. Forms and instructions for the proposal and final report are available in the EECS Undergraduate Office.
*A. P. Chandrakasan, D. M. Freeman*

Advanced Undergraduate Subjects and Graduate Subjects by Area

Systems Science and Control Engineering

6.207[J] Networks
Same subject as 14.15[J]
Prereq: 6.041 or 14.30
U (Spring)
4-0-8 units. HASS-S

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

6.215 Optimization Methods
Subject meets with 6.255[J], 15.093[J], IDS.200[J]
Prereq: 18.06
U (Fall)
4-0-8 units

Introduces the principal algorithms for linear, network, discrete, robust, nonlinear, and dynamic optimization. Emphasizes methodology and the underlying mathematical structures. Topics include the simplex method, network flow methods, branch and bound and cutting plane methods for discrete optimization, optimality conditions for nonlinear optimization, interior point methods for convex optimization, Newton’s method, heuristic methods, and dynamic programming and optimal control methods. Expectations and evaluation criteria differ for students taking graduate version; consult syllabus or instructor for specific details.
*D. Bertsimas, P. Parrilo*
6.231 Dynamic Programming and Reinforcement Learning
Prereq: 18.600 or 6.041
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[J]
Prereq: 6.003 and 18.06
G (Spring)
4-0-8 units

M. A. Dahleh, A. Megretski

Same subject as IDS.136[J]
Prereq: 6.431 and 18.06
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: G (Spring)
3-0-9 units
See description under subject IDS.136[J].

C. Uhler

6.245 Multivariable Control Systems
Prereq: 6.241[J] or 16.31
G (Fall)
Not offered regularly; consult department
3-0-9 units
Computer-aided design methodologies for synthesis of multivariable feedback control systems. Performance and robustness trade-offs. Model-based compensators; Q-parameterization; ill-posed optimization problems; dynamic augmentation; linear-quadratic optimization of controllers; H-infinity controller design; Mu-synthesis; model and compensator simplification; nonlinear effects. Computer-aided (MATLAB) design homework using models of physical processes.

A. Megretski

6.246, 6.247 Advanced Topics in Control
Prereq: Permission of instructor
G (Fall)
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
R. M. Freund, P. Parrilo, G. Perakis

6.254 Game Theory with Engineering Applications
Prereq: 6.431
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: G (Fall)
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 2019-2020: Not offered
Acad Year 2020-2021: G (Spring)
3-0-9 units
Theory and computational techniques for optimization problems involving polynomial equations and inequalities with particular, emphasis on the connections with semidefinite optimization. Develops algebraic and numerical approaches of general applicability, with a view towards methods that simultaneously incorporate both elements, stressing convexity-based ideas, complexity results, and efficient implementations. Examples from several engineering areas, in particular systems and control applications. Topics include semidefinite programming, resultants/discriminants, hyperbolic polynomials, Groebner bases, quantifier elimination, and sum of squares.
P. Parrilo

6.260, 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
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: 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

Same subject as 15.070[J]
Prereq: 6.431, 6.436[J], 18.100A, 18.100B, or 18.100Q
G (Spring)
Not offered regularly; consult department
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 2019-2020: G (Fall)
Acad Year 2020-2021: Not offered
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

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

6.321 Solid-State Circuits (New)
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

6.332, 6.333 Advanced Topics in Circuits
Prereq: Permission of instructor
G (Fall)
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

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 Numerical 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] Numerical Computing and Interactive Software
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

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
A. V. Oppenheim, J. Ward

6.344 Digital Image Processing
Prereq: 6.003 and 6.431
G (Spring)
3-0-9 units
J. S. Lim

6.345[J] Automatic Speech Recognition
Same subject as HST.728[J]
Prereq: 6.011 and 6.036
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: G (Spring)
3-1-8 units
Introduces the rapidly developing fields of automatic speech recognition and spoken language processing. Topics include acoustic theory of speech production, acoustic-phonetics, signal representation, acoustic and language modeling, search, hidden Markov modeling, neural networks models, adaptation, and other related speech processing topics. Lecture material intersperses theory with practice. Includes problem sets, laboratory exercises, and opened-ended term project.
J. R. Glass, V. W. Zue
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 2019-2020: G (Fall)  
Acad Year 2020-2021: Not offered  
3-3-6 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

6.419[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 (Fall)  
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.  
S. Jegelka

6.431 Introduction to Probability  
Subject meets with 6.041  
Prereq: Calculus II (GIR)  
G (Fall)  
4-0-8 units  
Credit cannot also be received for 15.079, 15.0791, 18.600  
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

Same subject as 15.085[J]  
Prereq: Calculus II (GIR)  
G (Fall)  
4-0-8 units  
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 (Fall)  
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.  
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 2019-2020: Not offered
Acad Year 2020-2021: 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 2019-2020: Not offered
Acad Year 2020-2021: 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
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 2019-2020: Not offered
Acad Year 2020-2021: 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

6.453 Quantum Optical Communication
Prereq: 6.011 and 18.06
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: G (Fall)
3-0-9 units

Quantum optics: Dirac notation quantum mechanics; harmonic oscillator quantization; number states, coherent states, and squeezed states; radiation field quantization and quantum field propagation; P-representation and classical fields. Linear loss and linear amplification: commutator preservation and the Uncertainty Principle; beam splitters; phase-insensitive and phase-sensitive amplifiers. Quantum photodetection: direct detection, heterodyne detection, and homodyne detection. Second-order nonlinear optics: phasematched interactions; optical parametric amplifiers; generation of squeezed states, photon-twin beams, non-classical fourth-order interference, and polarization entanglement. Quantum systems theory: optimum binary detection; quantum precision measurements; quantum cryptography; and quantum teleportation.

J. H. Shapiro
**6.454 Graduate Seminar in Area I**
Prereq: Permission of instructor
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: 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 2019-2020: G (Fall)
Acad Year 2020-2021: Not offered
3-2-7 units

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

**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.
J. Han, T. Heldt

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)
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: G (Fall)
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  
G (Spring)  
2-2-8 units  
Experimental investigations of speech processes. Topics include computer-aided 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.  
L. D. Braida, S. Shattuck-Hufnagel, J.-Y. Choi

6.544[J], 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

Same subject as HST.716[J]  
Prereq: (6.003 and (6.041B or 6.431)) or permission of instructor  
Acad Year 2019-2020: Not offered  
Acad Year 2020-2021: 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 tono-topic organization and stochastic responses of the auditory system. Mathematical models of psychophysical relations, incorporating quantitative knowledge of physiological transformations by the peripheral auditory system.  
L. D. Braida

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  
G (Spring)  
3-3-6 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 2019-2020: Not offered  
Acad Year 2020-2021: G (Fall)  
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

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
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: 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
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: 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
J. G. Fujimoto

6.632 Electromagnetic Wave Theory
Prereq: 6.013, 6.630, or 8.07
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: 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


J. G. Fujimoto

6.637 Optical Imaging Devices, and Systems
Subject meets with 6.161
Prereq: 6.003
G (Fall)
3-0-9 units

Principles of operation and applications of optical imaging devices and systems (includes optical signal generation, transmission, detection, storage, processing and display). Topics include review of the basic properties of electromagnetic waves; coherence and interference; diffraction and holography; Fourier optics; coherent and incoherent imaging and signal processing systems; optical properties of materials; lasers and LEDs; electrooptic 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)
3-0-9 units


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

6.644, 6.645 Advanced Topics in Applied Physics
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 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 2019-2020: G (Fall)
Acad Year 2020-2021: Not offered
3-0-9 units


J. L. Kirtley, Jr.
6.690 Introduction to Electric Power Systems
Subject meets with 6.061
Prereq: 6.002 and 6.013
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: 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
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
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: U (Fall)
4-0-8 units

Transistors at the nanoscale. Quantization, wavefunctions, and Schrödinger'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
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: G (Fall)
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
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: 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: 6.003 and 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 Schrödinger’s equation to the free particle, tunneling, the harmonic oscillator, and hydrogen atom. Variational methods. Elementary statistical physics; Fermi-Dirac, Bose-Einstein, and Boltzmann distribution functions. Simple models for metals, semiconductors, and devices such as electron microscopes, scanning tunneling microscope, thermonic emitters, atomic force microscope, and more.  
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 2019-2020: Not offered  
Acad Year 2020-2021: G (Spring)  
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  
Acad Year 2019-2020: Not offered  
Acad Year 2020-2021: G (Fall)  
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 fabrication 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 2019-2020: Not offered
Acad Year 2020-2021: 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 2019-2020: Not offered
Acad Year 2020-2021: U (Fall)
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 2019-2020: Not offered
Acad Year 2020-2021: 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

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 Fabrication
Prereq: 6.837 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
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
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: 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
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.
R. C. Miller, J. E. Greenberg, J. J. Leonard

6.812 Hardware Architecture for Deep Learning (New)
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[J])) or permission of instructor
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: 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
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: U (Spring)
4-0-8 units
Introduces principles and core techniques for programming multicore machines. Topics include locking, scalability, concurrent data structures, multiprocessor scheduling, load balancing, and state-of-the-art synchronization techniques, such as transactional memory. Includes sequence of programming assignments on a large multicore machine, culminating with the design of a highly concurrent application. Students taking graduate version complete additional assignments.
N. Shavit

6.817[J] Principles of Autonomy and Decision Making (New)
Same subject as 16.410[J]
Subject meets with 6.877[J], 16.413[J]
Prereq: 6.0002 or 6.01
U (Fall)
4-0-8 units
See description under subject 16.410[J].
B. C. Williams

6.818 Dynamic Computer Language Engineering (New)
Prereq: 6.004 or 6.031
U (Spring)
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[J])
U (Fall)
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 2019-2020: G (Fall)
Acad Year 2020-2021: Not offered
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
R. T. Morris, M. F. Kaashoek

6.825 Hardware Architecture for Deep Learning (New)
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[J])) or permission of instructor
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: 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[J], 6.141[J], 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 2019-2020: Not offered
Acad Year 2020-2021: 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[J] Cognitive Robotics
Same subject as 16.412[J]
Prereq: (6.034 or 16.413[J]) and (6.042[J], 16.09, or 6.041)
G (Spring)
3-0-9 units
See description under subject 16.412[J]. 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
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: G (Spring)
4-0-8 units
Introduces principles and core techniques for programming multicore machines. Topics include locking, scalability, concurrent data structures, multiprocessor scheduling, load balancing, and state-of-the-art synchronization techniques, such as transactional memory. Includes sequence of programming assignments on a large multicore machine, culminating with the design of a highly concurrent application. Students taking graduate version complete additional assignments.

N. Shavit

6.837 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)
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: 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

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 2019-2020: G (Fall)
Acad Year 2020-2021: Not offered
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 2019-2020: G (Spring)
Acad Year 2020-2021: Not offered
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 (New)
Subject meets with 6.034
Prereq: 6.0001
G (Fall)
4-3-5 units
Introduces representations, methods, and architectures used to build applications and to account for human intelligence from a computational point of view. Covers applications of rule chaining, constraint propagation, constrained search, inheritance, statistical inference, and other problem-solving paradigms. Also addresses applications of identification trees, neural nets, genetic algorithms, support-vector machines, boosting, and other learning paradigms. Considers what separates human intelligence from that of other animals. Students taking graduate version complete additional assignments.
P. H. Winston

6.845 Quantum Complexity Theory
Prereq: 6.045[J], 18.4041[J], and 18.435[J]
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[J] or permission of instructor
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: G (Spring)
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[J]
G (Spring)
3-0-9 units
P. Indyk
6.851 Advanced Data Structures
Prereq: 6.046[J]
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: G (Fall)
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 2019-2020: Not offered
Acad Year 2020-2021: G (Fall)
3-0-9 units

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

N. A. Lynch

6.853 Topics in Algorithmic Game Theory
Prereq: 6.006 or 6.046[J]
G (Spring)
3-0-9 units

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

K. Daskalakis

Same subject as 18.415[J]
Prereq: 6.046[J] and (6.041 or 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

6.856[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 2019-2020: Not offered
Acad Year 2020-2021: G (Spring)
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
G (Spring)
3-6-3 units

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

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
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: G (Fall)
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.
R. Barzilay, T. Jaakkola, L. Kaelbling

6.863[J] Natural Language and the Computer Representation of Knowledge
Same subject as 9.611[J]
Prereq: 6.034
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: 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 2019-2020: Not offered
Acad Year 2020-2021: G (Fall)
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 6.042[J])
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.
T. Jaakkola, L. P. Kaelbling

6.869 Advances in Computer Vision
Subject meets with 6.819
Prereq: 18.06 and (6.041B or 6.042[J])
G (Fall)
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 2019-2020: Not offered
Acad Year 2020-2021: 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

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 2019-2020: Not offered
Acad Year 2020-2021: 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

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 2019-2020: G (Spring)
Acad Year 2020-2021: Not offered
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]
G (Fall)
3-0-9 units
Can be repeated for credit.

In-depth exploration of recent results in cryptography.

S. Goldwasser, S. Micali, V. Vaikuntanathan

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

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 (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

6.883 Advanced Topics in Artificial Intelligence
Prereq: Permission of instructor
G (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

6.884 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

6.885-6.888 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

6.889-6.893 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

6.894-6.896 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 Engineering Innovation and Design
Engineering School-Wide Elective Subject.
Offered under: 2.723, 6.902, 16.662
Prereq: None
U (Fall, Spring)
2-1-3 units
Project-based seminar in innovative design thinking develops students’ ability to conceive, implement, and evaluate successful projects in any engineering discipline. Lectures focus on the iterative design process and techniques to enhance creative analysis. Students use this process to design and implement robust voice recognition applications using a simple web-based system. They also give presentations and receive feedback to sharpen their communication skills for high emotional and intellectual impact. Guest lectures illustrate multidisciplinary approaches to design thinking.
B. Kotely
Prereq: None
U (Spring)
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, licensing IP rights, the differences between US and international IP laws and enforcement mechanisms, and what rights an inventor does and does not obtain. Highlights current legal issues and trends relating to information technology, biogenetic materials, and business methods. Readings include judicial opinions and statutory material, and class participation includes patent drafting assignments, patentability opinions and courtroom presentation. No listeners.

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.
D. Doneson, B. L. Trout

6.904 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 and Tocqueville. Case studies include articles and films that address engineering disasters, safety, ethical codes, biotechnology, the internet and AI, and the ultimate scope and aims of engineering. 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.

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

6.907[J] Entrepreneurship in Engineering
Same subject as 2.913[J]
Subject meets with 6.933
Prereq: None
U (Spring)
4:0-8 units

Immerses students in the experience of an engineer who founds a start-up company. Examines leadership, innovation, and creativity through the lens of an entrepreneur. Suitable for students interested in transforming an idea into a business or other realization for wide-scale societal impact. Covers critical aspects of validating ideas and assessing personal attributes needed to activate and lead a growing organization. Teams explore the basics of new venture creation and experimentation. Emphasizes personal skills and practical experiences. Students taking graduate version will complete additional assignments. No listeners.

C. Chase
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[J], 16.667[J]
Prereq: None. Coreq: 6.912; or permission of instructor
U (Fall, Spring)
0-2-1 units
Can be repeated for credit.
Exposes students to leadership frameworks, models and cases within an engineering context, in an interactive, practice-based environment. Hones leadership, teamwork and communication skills. Students participate in guided reflections on individual and team successes, and discover opportunities for improvement in controlled settings. Activities include design-implement activities, role-plays, simulations, small group discussions, and performance and peer assessments by and of other students. Content throughout the term 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, J. Schindall, L. McGonagle

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.
Exposes students to leadership frameworks, models and cases within an engineering context, in an interactive, practice-based environment. Hones leadership, teamwork and communication skills. Students lead and participate in guided reflections on individual and team successes, and discover opportunities for improvement in controlled settings. Activities include leading and supporting design-implement activities, role-plays, simulations, small group discussions, and performance and peer assessments by and of other students. Content throughout the term 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 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)
1-2-1 units

Students attend a four-day off-site workshop where an introduction to basic principles, methods, and tools for project management in a realistic context are covered. In teams, students create a plan for a project of their choice in one of several areas, including aircraft modification, factory automation, enterprise software, flood prevention engineering, solar farm engineering, among others. Develops skills applicable to the management of complex development projects. Topics include cost-benefit analysis, resource and cost estimation, and project control and delivery, which are practiced during an experimental, team-based activity. Case studies highlight projects in both hardware/construction and software. Preference to students in the Bernard M. Gordon-MIT Engineering Leadership Program.

O. de Weck, J. Feiler, L. McGonagle, R. Rahaman

**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

**6.915[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

**6.921 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
6.928J Leading Creative Teams
Same subject as 15.674[J], 16.990[J]
Prereq: None
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 professional skill development.
D. Nino, J. Schindall

6.929J Energy Technology and Policy: From Principles to Practice
Same subject as 5.00[J], 10.579[J], 22.813[J]
Prereq: None
G (Spring)
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

6.933 Entrepreneurship in Engineering
Subject meets with 2.913[J], 6.907[J]
Prereq: None
G (Spring)
4-0-8 units
Immerses students in the experience of an engineer who founds a start-up company. Examines leadership, innovation, and creativity through the lens of an entrepreneur. Suitable for students interested in transforming an idea into a business or other realization for wide-scale societal impact. Covers critical aspects of validating ideas and assessing personal attributes needed to activate and lead a growing organization. Teams explore the basics of new venture creation and experimentation. Emphasizes personal skills and practical experiences. Students taking graduate version will complete additional assignments. No listeners.
C. Chase

6.934J Engineering, Economics and Regulation for Energy Access in Developing Countries
Same subject as 15.017[J]
Prereq: None
Acad Year 2019-2020: Not offered
Acad Year 2020-2021: G (Spring)
3-0-9 units
See description under subject 15.017[J].
I. Perez-Arriaga, R. Stoner

6.935J Financial Market Dynamics and Human Behavior
Same subject as 15.481[J]
Prereq: 15.401, 15.414, or 15.415
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. Lavallee, 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

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. Kolodziejski
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. Kolodziejski

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. Kolodziejksi

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

6.999 Practical Experience in EECS
Prereq: None
G (Fall, Spring)
Units arranged [P/D/F]

For Course 6 students in the SM/PhD track who seek practical off-campus research experiences or internships in electrical engineering or computer science. Before enrolling, students must have a firm employment offer from a company or organization and secure a research supervisor within EECS. Employers required to document the work accomplished. Research proposals subject to departmental approval; consult departmental Graduate Office.
L. A. Kolodziejski

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.S897-6.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.S911-6.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
Prereq: None
G (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

Opportunity for study of graduate-level topics related to electrical engineering and computer science but not included elsewhere in the curriculum. Registration under this subject normally used for situations involving small study groups. Normal registration is for 12 units. Registration subject to approval of professor in charge. Consult the department for details.
Consult Department

6.S974 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Fall)
Not offered regularly; consult department
Units arranged
Can be repeated for credit.

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

6.S975 Special Subject in Electrical Engineering and Computer Science
Prereq: None
G (Fall, IAP)
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.S976 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.S977 Special Subject in Electrical Engineering and Computer Science
Prereq: Permission of instructor
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.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.
L. A. Kolodziejski

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