Department of Electrical Engineering and Computer Science

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Electrical Engineering and Computer Science is a broad field of study reaching from physical electronic devices all the way up to complex computer software. It encompasses diverse subject areas such as photonics, electromagnetics, physics of semiconductor devices, analog, digital, and power electronics and circuits, communication and signal processing, as well as digital hardware and software systems, computer systems and networks, and distributed computing. Knowledge of the mathematical and natural sciences is applied to the theory, design, and implementation of electronic devices and systems for the benefit of society.

The Department offers three undergraduate degrees: Electrical Engineering, Computer Engineering, as well as Computer Science and Engineering. Computer Science and Engineering is offered in conjunction with the Donald Bren School of Information and Computer Sciences; information is available in the Interdisciplinary Studies section of the UCI General Catalogue (http://catalogue.uci.edu/interdisciplinarystudies/).

Some electrical engineers focus on the study of electronic devices and circuits that are the basic building blocks of complex electronic systems. Others study power electronics and the generation, transmission, and utilization of electrical energy. A large group of electrical engineers studies the application of these complex systems to other areas, including medicine, biology, geology, and ecology. Still another group studies complex electronic systems such as automatic controls, telecommunications, wireless communications, and signal processing.

Computer engineers are trained in various fields of computer science and engineering. They engage in the design and analysis of digital computers and networks, including software and hardware systems. Computer design includes topics such as computer architecture, embedded systems, design automation, system software, data structures and algorithms, computer networks, and cloud computing. Computer Engineering courses include programming in high-level languages such as Python, C/C++ and Java; design of application and system software; design of hardware/software interfaces and embedded systems; and application of computers in solving engineering problems. Laboratories in both hardware and software experiences are integrated within the Computer Engineering curriculum.

The undergraduate curriculum in Electrical Engineering and Computer Engineering provides a solid foundation for future career growth, enabling graduates' careers to grow technically, administratively, or both. Many electrical and computer engineers will begin work in a large organizational environment as members of an engineering team, obtaining career satisfaction from solving meaningful problems that contribute to the success of the organization's overall goal. As their careers mature, technical growth most naturally results from the acquisition of an advanced degree and further development of the basic thought processes instilled in the undergraduate years. Administrative growth can result from the development of management skills on the job and/or through advanced degree programs in management.

Graduates of Electrical Engineering, Computer Engineering, and Computer Science and Engineering will find a variety of career opportunities in areas including wireless communication, voice and video coding, biomedical electronics, circuit design, optical devices and communication, semiconductor devices and fabrication, power systems, power electronics, computer hardware and software design, computer networks, design of embedded computer systems, application software, data storage and retrieval, pattern recognition, computer modeling, and parallel and cloud computing.

- Computer Engineering, B.S.
- Computer Science and Engineering, B.S.
- Electrical and Computer Engineering, M.S.
- Electrical and Computer Engineering, Ph.D.
- Electrical Engineering, B.S.

Faculty

Hamidreza Aghasi, Ph.D. Cornell University, *Assistant Professor of Electrical Engineering and Computer Science* (analog circuit design, mm-wave and terahertz integrated circuits, high resolution integrated sensing and imaging, neuromorphic computation, emerging device technologies)

Mohammad Al Faruque, Ph.D. University of Kaiserslautern, *Chair of Emulex Career Development and Professor of Electrical Engineering and Computer Science; Computer Science; Mechanical and Aerospace Engineering* (cyber-physical systems, internet of things, embedded systems, CPS security)

Ender Ayanoglu, Ph.D. Stanford University, *Professor of Electrical Engineering and Computer Science* (communication systems, communication theory, communication networks)

Nader Bagherzadeh, Ph.D. University of Texas at Austin, *Professor of Electrical Engineering and Computer Science; Computer Science* (parallel processing, computer architecture, computer graphics, memory systems, 3-D ICs, heterogeneous computing, low-power processing)

Ozdal Boyraz, Ph.D. University of Michigan, *Professor of Electrical Engineering and Computer Science* (integrated optics, silicon photonics, optical communications systems, and microwave photonics)

Peter J. Burke, Ph.D. Yale University, *Professor of Electrical Engineering and Computer Science; Biomedical Engineering; Materials Science and Engineering* (nano-electronics, bio-nanotechnology)

Hung Cao, Ph.D. University of Texas at Arlington, *Associate Professor of Electrical Engineering and Computer Science; Biomedical Engineering* (MEMS, sensors, implants, heart disease, neurological disease, wireless biomedical systems)

Filippo Capolino, Ph.D. University of Florence, *Professor of Electrical Engineering and Computer Science* (optics/electromagnetics in nanostructures and sensors, antennas/microwaves, RF and wireless systems)

Aparna Chandramowlishwaran, Ph.D. Georgia Institute of Technology, *Associate Professor of Electrical Engineering and Computer Science; Mechanical and Aerospace Engineering* (high-performance computing, domain-specific compilers, algorithm-architecture co-design, data analysis, and scientific computing)

Quoc-Viet Dang, Ph.D. University of California, Irvine, *Associate Professor of Teaching of Electrical Engineering and Computer Science* (e-learning, data analysis, autonomous vehicle racing, cyber-physical systems, making the world a better place)

Franco De Flaviis, Ph.D. University of California, Los Angeles, *Professor of Electrical Engineering and Computer Science* (microwave systems, wireless communications, electromagnetic circuit simulations)

Rainer B. Doemer, Ph.D. Dortmund University, *Professor of Electrical Engineering and Computer Science; Computer Science* (system-level design, embedded computer systems, design methodologies, specification and modeling languages, advanced parallel simulation, integration of hardware and software systems)

Magnus Egerstedt, Ph.D. KTH Royal Institute of Technology, *Stacey Nicholas Dean of Engineering and Professor of Electrical Engineering and Computer Science; Mechanical and Aerospace Engineering* (Control theory and robotics, control and coordination of complex networks, multirobot systems, mobile sensor networks and cyber-physical systems)

Salma Elmalaki, Ph.D. University of California, Los Angeles, *Assistant Professor of Teaching of Electrical Engineering and Computer Science* (mobile computing, pervasive autonomous system, personalized computing, and internet-of-things (IoT))

Rahim Esfandyarpour, Ph.D. Stanford University, *Assistant Professor of Electrical Engineering and Computer Science; Biomedical Engineering* (nanotechnology and nanoscience, flexible electronics, MEMS and NEMS fabrication and modeling, stretchable and wearable bio devices, translational micro/nanotechnologies, biological and chemical sensors, microfluidics, microelectronics circuits and systems, physiological monitoring, Internet of Things (IOT) bio devices, technology development for personalized/precision medicine, and Point of Care (POC) diagnostics)

Daniel D. Gajski, Ph.D. University of Pennsylvania, *Professor Emeritus of Electrical Engineering and Computer Science* (embedded systems, software/hardware design, design methodologies and tools, science of design)

Jean-Luc Gaudiot, Ph.D. University of California, Los Angeles, *Distinguished Professor of Electrical Engineering and Computer Science; Computer Science* (parallel processing, computer architecture, processor architecture)

Michael M. Green, Ph.D. University of California, Los Angeles, *Professor of Electrical Engineering and Computer Science* (analog/mixed-signal IC design, broadband circuit design, theory of nonlinear circuits)

Glenn E. Healey, Ph.D. Stanford University, *Professor of Electrical Engineering and Computer Science* (machine learning, data science, sabermetrics, physical modeling, computer vision, image processing)

Payam Heydari, Ph.D. University of Southern California, *UCI Chancellor's Professor of Electrical Engineering and Computer Science; Biomedical Engineering* (design and analysis of analog, radio-frequency, millimeter-wave and terahertz integrated circuits)

Sitao Huang, Ph.D. University of Illinois at Urbana-Champaign, *Assistant Professor of Electrical Engineering and Computer Science* (hardware architecture and system optimization for high performance computing)

Syed A. Jafar, Ph.D. Stanford University, *Professor of Electrical Engineering and Computer Science* (wireless communication and information theory)

Hamid Jafarkhani, Ph.D. University of Maryland, College Park, *Conexant-Broadcom Chair in the Center for Pervasive Communications and UCI Chancellor's Professor of Electrical Engineering and Computer Science* (communication theory, signal processing coding, wireless networks, medical image segmentation)

Pramod Khargonekar, Ph.D. University of Florida, *UCI Distinguished Professor of Electrical Engineering and Computer Science* (systems and control theory; learning and intelligent systems; applications to renewable energy and smart grid, neural engineering, and economics; leadership and creativity; technology and society)

Stuart A. Kleinfelder, Ph.D. Stanford University, *Professor Emeritus of Electrical Engineering and Computer Science* (circuits and systems for visual imaging, X-rays, electron microscopy, particle physics, and other applications)

Fadi J. Kurdahi, Ph.D. University of Southern California, *Director, Center for Embedded Computer Systems and Associate Dean for Graduate and Professional Studies and Professor of Electrical Engineering and Computer Science; Computer Science* (embedded and cyber-physical systems, VLSI system design, design automation of digital systems)

Hyoukjun Kwon, Ph.D. Georgia Institute of Technology, *Assistant Professor of Electrical Engineering and Computer Science* (deep learning accelerators with flexible dataflow and mappings based on data- and communication-centric approaches)

Guann-Pyng Li, Ph.D. University of California, Los Angeles, *Director of the UCI Division of the California Institute for Telecommunications and Information Technology (Calit2), Director of the Integrated Nanosystems Research Facility and Professor of Electrical Engineering and Computer Science; Biomedical Engineering* (micro/nano technology for sensors and actuators, internet of things (IoT), smart manufacturing, biomedical devices and millimeter wave wireless communication)

Zhou Li, Ph.D. Indiana University Bloomington, *Assistant Professor of Electrical Engineering and Computer Science* (data-driven security analytics, internet measurement, side-channel analysis, IoT security)

Kwei-Jay Lin, Ph.D. University of Maryland, College Park, *Professor Emeritus of Electrical Engineering and Computer Science; Computer Science* (real-time systems, distributed systems, service-oriented computing)

Athina Markopoulou, Ph.D. Stanford University, *Professor of Electrical Engineering and Computer Science; Computer Science* (networking: including network protocols, network measurement and analysis, mobile systems and mobile data analysis, network security and privacy)

Henry Samueli, Ph.D. University of California, Los Angeles, *Adjunct Professor of Electrical Engineering and Computer Science* (digital signal processing, communications systems engineering, CMOS integrated circuit design for applications in high-speed data transmission systems)

Terence Sanger, M.D. Harvard Medical School, *Vice President and Chief Scientific Officer for Children's Hospital Orange County and Professor of Electrical Engineering and Computer Science; Biomedical Engineering*

Maxim Shcherbakov, Ph.D. Lomonosov Moscow State University, *Assistant Professor of Electrical Engineering and Computer Science* (nanophotonics, nonlinear and quantum optics, nanofabrication, strong-#eld physics, ultrafast processes)

Yanning Shen, Ph.D. University of Minnesota, *Assistant Professor of Electrical Engineering and Computer Science* (machine learning, data science, network science, and statistical-signal processing)

Phillip C-Y Sheu, Ph.D. University of California, Berkeley, *Professor of Electrical Engineering and Computer Science; Biomedical Engineering; Computer Science* (semantic computing, robotic computing, artificial intelligence, biomedical computing, multimedia computing)

Yasser Shoukry, Ph.D. University of California, Los Angeles, *Associate Professor of Electrical Engineering and Computer Science* (resilience, safety, security and privacy of artificial intelligence (AI), controlled cyber-physical systems (CPS), internet-of-things (IoT), and robotic systems)

Keyue M. Smedley, Ph.D. California Institute of Technology, *Professor of Electrical Engineering and Computer Science* (power electronics, renewables, energy storage and grid stabilization)

A. Lee Swindlehurst, Ph.D. Stanford University, *Department Chair and Distinguished Professor of Electrical Engineering and Computer Science* (signal processing, estimation and detection theory, applications in wireless communications, geo-positioning, radar, sonar, biomedicine)

Chen S. Tsai, Ph.D. Stanford University, *Distinguished Professor Emeritus of Electrical Engineering and Computer Science* (integrated microwave magnetics, Ultrasonic Atomization for Nanoparticles Synthesis, silicon photonics)

Peter Tseng, Ph.D. University of California, Los Angeles, *Associate Professor of Electrical Engineering and Computer Science; Biomedical Engineering* ((bio) Micro-Electro-Mechanical systems, wearable technology, materials-by-design, bioelectromagnetism, nanotechnology)

Zhiying Wang, Ph.D. California Institute of Technology, *Associate Professor of Electrical Engineering and Computer Science* (information theory, coding theory for data storage, modeling, compression, and computation for genomic data)

H. Kumar Wickramasinghe, Ph.D. University of London, *Henry Samueli Endowed Chair in Engineering and Professor Emeritus of Electrical Engineering and Computer Science; Biomedical Engineering; Materials Science and Engineering* (nanoscale measurements and characterization, scanning probe microscopy, storage technology, nano-bio measurement technology)

Homayoun Yousefi'zadeh, Ph.D. University of Southern California, *Adjunct Professor of Electrical Engineering and Computer Science* (communications networks)

Affiliate Faculty

Carter Butts, Ph.D. Carnegie Mellon University, *Chancellor's Professor of Sociology; Computer Science; Electrical Engineering and Computer Science; Statistics* (mathematical sociology, social networks, quantitative methodology, human judgment and decision making, economic sociology)

Qi Alfred Chen, Ph.D. University of Michigan, *Assistant Professor of Computer Science; Electrical Engineering and Computer Science* (smart systems and IoT)

Brian Demsky, Ph.D. Massachusetts Institute of Technology, *Professor of Computer Science; Electrical Engineering and Computer Science* (software reliability, security, software engineering, compilation, parallel software, program analysis, and program understanding)

Nikil D. Dutt, Ph.D. University of Illinois at Urbana–Champaign, *UCI Distinguished Professor of Computer Science; Cognitive Sciences; Electrical Engineering and Computer Science* (embedded systems, computer architecture, electronic design automation, software systems, brain-inspired architectures and computing)

Aleksandr Figotin, Ph.D. Tashkent University of Information Technologies, *Professor of Mathematics; Electrical Engineering and Computer Science* (applied and computational mathematics, mathematical physics)

Michael S. Franz, Ph.D. Swiss Federal Institute of Technology in Zurich, *UCI Chancellor's Professor of Computer Science; Electrical Engineering and Computer Science* (systems software, particularly compilers and virtual machines, trustworthy computing, software engineering)

Gultekin Gulsen, Ph.D. Bogazici University, *Associate Professor of Radiological Sciences; Biomedical Engineering; Electrical Engineering and Computer Science; Physics and Astronomy*

Ian G. Harris, Ph.D. University of California, San Diego, *Professor of Computer Science; Electrical Engineering and Computer Science* (hardware/software covalidation, manufacturing test)

Scott A. Jordan, Ph.D. University of California, Berkeley, *Professor of Computer Science; Electrical Engineering and Computer Science* (pricing and differentiated services in the Internet, resource allocation in wireless networks, telecommunications policy)

Arash Kheradvar, Ph.D. California Institute of Technology, *Professor of Biomedical Engineering; Electrical Engineering and Computer Science; Mechanical and Aerospace Engineering* (cardiac mechanics, cardiovascular devices, cardiac imaging)

Michelle Khine, Ph.D. University of California, Berkeley, *Professor of Biomedical Engineering; Electrical Engineering and Computer Science* (development of novel nano- and micro-fabrication technologies and systems for single cell analysis, stem cell research, in-vitro diagnostics)

Marco Levorato, Ph.D. University of Padua, *Associate Professor of Computer Science; Electrical Engineering and Computer Science* (artificial intelligence and machine learning, networks and distributed systems, statistics and statistical theory, stochastic modeling, signal processing)

Sabee Y. Molloi, Ph.D. University of Wisconsin-Madison, *Professor of Radiological Sciences; Biomedical Engineering; Electrical Engineering and Computer Science*

Zoran Nenadic, D.Sc. Washington University, *William J. Link Department Chair and Professor of Biomedical Engineering; Electrical Engineering and Computer Science* (adaptive biomedical signal processing, control algorithms for biomedical devices, brain-machine interfaces, modeling and analysis of biological neural networks)

Eric Potma, Ph.D. University of Groningen, *Professor of Chemistry; Biomedical Engineering; Electrical Engineering and Computer Science* (analytical, chemical biology, physical chemistry and chemical physics)

Amir M. Rahmani, Ph.D. University of Turku, Finland, *Professor of Nursing; Electrical Engineering and Computer Science*

Ardalan Amiri Sani, Ph.D. Rice University, *Assistant Professor of Computer Science; Electrical Engineering and Computer Science* (involves building efficient, high performance, and reliable systems)

Andrei M. Shkel, Ph.D. University of Wisconsin-Madison, *Professor of Mechanical and Aerospace Engineering; Biomedical Engineering; Electrical Engineering and Computer Science* (design and advanced control of micro-electro-mechanical systems (MEMS); high precision micro-machined gyroscopes; MEMS-enhanced optical systems, tools and prosthetic appliances; electromechanical and machine-information systems integration)

Sameer Singh, Ph.D. University of Massachusetts Amherst, *Associate Professor of Computer Science; Electrical Engineering and Computer Science; Language Science* (artificial intelligence and machine learning, databases and data mining, scientific and numerical computing)

William C. Tang, Ph.D. University of California, Berkeley, *Professor of Biomedical Engineering; Chemical and Biomolecular Engineering; Electrical Engineering and Computer Science; Materials Science and Engineering* (micro-electro-mechanical systems (MEMS) nanoscale engineering for biomedical applications, microsystems integration, microimplants, microbiomechanics, microfluidics)

Camilo Velez Cuervo, Ph.D. University of Florida, *Assistant Professor of Mechanical and Aerospace Engineering; Electrical Engineering and Computer Science* (micro/nano robotics, micro/nano device fabrication, microfabrication of magnetic microsystems, magnetic micro/nanostructures, selective magnetization of micro patterns, microsystems (MEMS), biomedical microsystems, semiconductor devices and microfluidics)

Yoon Jin Won, Ph.D. Stanford University, *Associate Professor of Mechanical and Aerospace Engineering; Electrical Engineering and Computer Science; Materials Science and Engineering* (multi-scale structures for thermal and energy applications, in particular fabrication, characterization, and integration of structured materials)

Courses

EECS 1. Introduction to Electrical Engineering and Computer Engineering. 1 Unit.
Introduction to the fields of Electrical Engineering and Computer Engineering, including possible careers in both traditional and new emerging areas. Background on both the Electrical Engineering and the Computer Engineering majors, curriculum requirements, specializations, and faculty research interests.

(Design units: 0)

Restriction: Electrical Engineering Majors have first consideration for enrollment.

EECS 10. Computational Methods in Electrical and Computer Engineering. 4 Units.
An introduction to computers and structured programming. Binary Data Representation. Hands-on experience with a high-level structured programming language. Introduction to algorithm efficiency. Applications of structured programming in solving engineering problems. Programming laboratory.

(Design units: 0)

Corequisite: MATH 2A
Prerequisite: MATH 2A or AP Calculus AB. AP Calculus AB with a minimum score of 3

Overlaps with EECS 12.

Restriction: Chemical Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment.

EECS 12. Introduction to Programming. 4 Units.
An introduction to computers and programming. Python programming syntax/style, types. Numbers and sequences. Control flow. I/O and errors/exceptions. Function calling, parameter passing, formal arguments, return values. Variable scoping. Programming laboratory.

(Design units: 0)

Corequisite: MATH 2A
Prerequisite: MATH 2A or AP Calculus AB. AP Calculus AB with a minimum score of 3

Overlaps with EECS 10.

Restriction: Computer Engineering Majors have first consideration for enrollment.

EECS 20. Computer Systems and C Programming. 4 Units.
Introduction to computing systems. Data representation and operations. Simple logic design. Basic computer organization. Instruction set architecture and assembly language programming. Introduction to C. Functions and recursion, data structures, pointers. Programming laboratory.

(Design units: 1)

Prerequisite: EECS 12

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 22. Advanced C Programming. 3 Units.
C language programming concepts. Control flow, function calls, recursion. Basic and composite data types, static and dynamic data structures. Program modules and compilation units. Preprocessor macros. C standard libraries.

(Design units: 1)

Prerequisite: EECS 10 or EECS 20

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 22L. Software Engineering Project in C Language. 3 Units.
Hands-on experience with the ANSI-C programming language. Medium-sized programming projects, team work. Software specification, documentation, implementation, testing. Definition of data structures and application programming interface. Creation of program modules, linking with external libraries. Rule-based compilation, version control.

(Design units: 3)

Prerequisite: EECS 22

Restriction: Computer Engineering Majors have first consideration for enrollment.

EECS 31. Introduction to Digital Systems. 4 Units.
Digital representation of information. Specification, analysis, design and optimization or combinational and sequential logic, register-transfer components and register-transfer systems with datapaths and controllers. Introduction to high-level and algorithmic state-machines and custom processors.

(Design units: 2)

Prerequisite: ICS 31 or EECS 10 or EECS 12 or MAE 10 or ICS 32A

Restriction: Computer Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment.

EECS 31L. Introduction to Digital Logic Laboratory. 3 Units.
Introduction to common digital integrated circuits: gates, memory circuits, MSI components. Operating characteristics, specifications, applications. Design of simple combinational and sequential digital systems (arithmetic processors game-playing machines). Construction and debugging techniques using hardware description languages and CAD tools.

(Design units: 3)

Prerequisite: EECS 31 and (EECS 10 or EECS 12 or ICS 32)

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 40. Object-Oriented Systems and Programming. 4 Units.
Primitive types and expressions. The class and method definition. Information hiding and encapsulation. Objects and reference. Overloading. Constructors. Inheritance basics. Programming with inheritance. Dynamic binding and polymorphism. Exception handling. An overview of streams and file input/output. Programming laboratory.

(Design units: 2)

Prerequisite: EECS 22L

Restriction: Computer Engineering Majors have first consideration for enrollment.

EECS 50. Discrete-Time Signals and Systems. 4 Units.
Analysis of discrete-time linear-time-invariant (DTLTI) systems in the time domain and using z-transforms. Introduction to techniques based on Discrete-Time, Discrete, and Fast Fourier Transforms. Examples of their application to digital signal processing and digital communications.

(Design units: 0)

Prerequisite: EECS 70A

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 55. Engineering Probability. 4 Units.
Sets and set operations; nature of probability, sample spaces, fields of events, probability measures; conditional probability, independence, random variables, distribution functions, density functions, conditional distributions and densities; moments, characteristic functions, random sequences, independent and Markov sequences.

(Design units: 0)

Prerequisite: MATH 2D

Restriction: Computer Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment.

EECS 70A. Network Analysis I. 4 Units.
Modeling and analysis of electrical networks. Basic network theorems. Sinusoidal steady state and transient analysis of RLC networks and the impedance concept.

(Design units: 1)

Corequisite: MATH 3D
Prerequisite: PHYS 7D and (EECS 10 or EECS 12 or MAE 10 or ICS 31 or CEE 20)

Overlaps with MAE 60.

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

EECS 70B. Network Analysis II. 4 Units.
Laplace transforms, complex frequency, and the s-plane. Network functions and frequency response, including resonance. Bode plots. Two-port network characterization.

(Design units: 1)

Corequisite: EECS 70LB
Prerequisite: (BME 60B or EECS 10 or EECS 12 or ICS 31 or CEE 20 or MAE 10) and EECS 70A

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment.

EECS 70LA. Network Analysis I Laboratory. 1 Unit.
Laboratory to accompany EECS 70A.

(Design units: 0)

Corequisite: EECS 70A
Prerequisite: PHYS 7D and (EECS 10 or EECS 12 or BME 60B or CEE 20 or MAE 10)

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 70LB. Network Analysis II Laboratory. 1 Unit.
Laboratory to accompany EECS 70B. Materials fee.

(Design units: 1)

Corequisite: EECS 70B
Prerequisite: (BME 60B or EECS 10 or EECS 12 or ICS 31 or CEE 20 or MAE 10) and EECS 70A

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 101. Introduction to Machine Vision. 3 Units.
The use of digital computers for the analysis of visual scenes; image formation and sensing, color, segmentation, shape estimation, motion, stereo, pattern classification, computer architectures, applications. Computer experiments are used to illustrate fundamental principles.

(Design units: 2)

Prerequisite: EECS 150 or EECS 50

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 111. System Software. 4 Units.
Multiprogramming, interrupt, processes, kernel, parallelism, critical sections, deadlocks, communication, multiprocessing, multilevel memory management, binding, name management, file systems, protection, resource allocation, scheduling. Experience with concurrent programming, synchronization mechanisms, interprocess communication.

(Design units: 2)

Prerequisite: EECS 112 and (ICS 46 or EECS 114)

Overlaps with CS 143A.

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 112. Organization of Digital Computers. 4 Units.
Building blocks and organization of digital computers, the arithmetic, control, and memory units, and input/out devices and interfaces. Microprogramming and microprocessors.

(Design units: 4)

Prerequisite: EECS 31L

Overlaps with CS 152.

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 112L. Organization of Digital Computers Laboratory. 3 Units.
Specification and implementation of a processor-based system using a hardware description language such as VHDL. Hands-on experience with design tools including simulation, synthesis, and evaluation using testbenches.

(Design units: 3)

Prerequisite: EECS 112

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 113. Processor Hardware/Software Interfaces. 4 Units.
Hardware/software interfacing, including memory and bus interfaces, devices, I/O, and compiler code generation/instruction scheduling. Experience microcontroller programming and interfacing. Specific compiler code generation techniques including local variable and register allocations, instruction dependence and scheduling, and code optimization.

(Design units: 3)

Prerequisite: EECS 112

Restriction: Computer Engineering Majors have first consideration for enrollment. Computer Science and Engineering Majors have second consideration for enrollment.

EECS 114. Engineering Data Structures and Algorithms. 4 Units.
Introduces abstract behavior of classes data structures, alternative implementations, informal analysis of time and space efficiency. Also introduces classic algorithms and efficient algorithm design techniques (recursion, divide-and-conquer, branch-and-bound, dynamic programming).

(Design units: 2)

Prerequisite: EECS 40

Restriction: Computer Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

EECS 116. Introduction to Data Management. 4 Units.
Introduction to the design of databases and the use of database management systems (DBMS) for applications. Topics include entity-relationship modeling for design, relational data model, relational algebra, relational design theory, and Structured Query Language (SQL) programming.

(Design units: 1)

Prerequisite: ICS 33 or EECS 114. ICS 33 with a grade of C or better

Same as CS 122A.

Restriction: School of Info & Computer Sci students have first consideration for enrollment. Computer Science Engineering Majors have first consideration for enrollment.

EECS 117. Parallel Computer Systems. 3 Units.
General introduction to parallel computing focusing on parallel algorithms and architectures. Parallel models: Flynn's taxonomy, dataflow models. Parallel architectures: systolic arrays, hypercube architecture, shared memory machines, dataflow machines, reconfigurable architectures. Parallel algorithms appropriate to each machine type area also discussed.

(Design units: 1)

Prerequisite: EECS 20 and EECS 114 and EECS 112

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 118. Data and Knowledge Science and Engineering. 4 Units.
Introduction of basic concepts in artificial intelligence. Knowledge representation and reasoning, search, planning, declarative programing, problem solving, and data science.

(Design units: 2)

Prerequisite: EECS 114

Overlaps with CS 171.

Restriction: Computer Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

EECS 119. VLSI. 4 Units.
Design techniques for Very Large Scale Integrated (VLSI) systems and chips. Review CMOS and related process technologies; primitives such as logic gates and larger design blocks; layout; floor planning; design hierarchy, component interfaces; use of associated CAD tools for design.

(Design units: 4)

Prerequisite: EECS 112 and EECS 170B

Overlaps with EECS 170D, CSE 112.

Restriction: Computer Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

EECS 120. Fundamentals of Parallel Computing. 4 Units.
Fundamentals of parallel computing, focusing on parallel algorithms and architectures. Topics include design of parallel and I/O efficient algorithms, basics of parallel machine architectures, and current/emerging programming models (shared memory, distributed memory, and accelerators).

Prerequisite: (EECS 12 or CS 152) and EECS 114

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 121. System Security. 3 Units.
Fundamentals and practices of system security. Topics include cryptographic (encryption, decryption, and message authentication), software vulnerabilities (buffer overflow), network security (layer 2-7 attacks and defenses and PKI), web security (XSS and XSRF), and privacy.

Prerequisite: EECS 22 or ICS 45C

EECS 125. Introduction to Machine Learning for Engineers. 4 Units.
Introduction to ML with a special focus on engineering applications. Starts with a mathematical background required for ML and covers various models for supervised learning (classification and regression) and unsupervised learning (clustering).

Prerequisite: EECS 55 and EECS 145 and EECS 12. Recommended: EECS 114.

Overlaps with CS 178.

EECS 141A. Communication Systems I. 3 Units.
Introduction to analog communication systems including effects of noise. Modulation-demodulation for AM, DSB-SC, SSB, VSB, QAM, FM, PM, and PCM with application to radio, television, and telephony. Signal processing as applied to communication systems.

(Design units: 1)

Prerequisite: EECS 55 and EECS 150

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 141B. Communication Systems II. 3 Units.
Signal space analysis. Optimum receivers for digital communication. Maximum a posteriori and maximum likelihood detection. Matched filter and correlation receiver. PAM, QAM, PSK, FSK, and MSK and their performance. Introduction to equalization, synchronization, information theory, and error control codes.

(Design units: 1)

Prerequisite: EECS 141A

Restriction: Computer Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have first consideration for enrollment.

EECS 144. Antenna Design for Wireless Communication Links. 4 Units.
Analysis and synthesis of antennas and antenna arrays. Adaptive arrays and digital beam forming for advanced wireless links. Friis transmission formula. Wireless communication equations for cell-site and mobile antennas, interference, slow and fast fading in mobile communication.

(Design units: 0)

Prerequisite: EECS 180A

EECS 145. Electrical Engineering Analysis. 4 Units.
Vector calculus, complex functions, and linear algebra with applications to electrical engineering problems.

(Design units: 0)

Prerequisite: MATH 3D

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment. Computer Science Engineering majors have second consideration for enrollment.

EECS 148. Computer Networks. 4 Units.
Computer network architectures, protocols, and applications. Internet congestion control, addressing, and routing. Local area networks. Multimedia networking.

(Design units: 2)

Prerequisite: EECS 55 or STAT 67

Same as CS 132.

Restriction: Computer Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have first consideration for enrollment.

EECS 150. Continuous-Time Signals and Systems. 4 Units.
Characteristics and properties of continuous-time (analog) signals and systems. Analysis of linear time-invariant continuous-time systems using differential equation convolutional models. Analysis of these systems using Laplace transforms, Fourier series, and Fourier transforms. Examples from applications to telecommunications.

(Design units: 0)

Prerequisite: EECS 70A and MATH 3D

Restriction: Computer Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

EECS 152A. Digital Signal Processing. 3 Units.
Nature of sampled data, sampling theorem, difference equations, data holds, z-transform, w-transform, digital filters, Butterworth and Chebychev filters, quantization effects.

(Design units: 2)

Prerequisite: EECS 50

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 152B. Digital Signal Processing Design and Laboratory. 3 Units.
Design and implementation of algorithms on a DSP processor and using computer simulation. Applications in signal and image processing, communications, radar, etc.

(Design units: 3)

Prerequisite: EECS 152A

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 159A. Senior Design Project I. 3 Units.
Teaches problem definition, detailed design, integration, and testability with teams of students specifying, designing, building, and testing complex systems. Lectures include engineering values, discussions, and ethical ramifications of engineering decisions.

(Design units: 3)

Prerequisite: EECS 113 or EECS 170C or CS 145

Restriction: Seniors only. Computer Science Engineering Majors only. Electrical Engineering Majors only. Computer Engineering Majors only.

EECS 159B. Senior Design Project II. 3 Units.
Teaches problem definition, detailed design, integration, and testability with teams of students specifying, designing, building, and testing complex systems. Lectures include engineering values, discussions, and ethical ramifications of engineering decisions. Materials fee.

(Design units: 3)

Prerequisite: EECS 159A

Restriction: Computer Science Engineering Majors only. Electrical Engineering Majors only. Computer Engineering Majors only.

EECS 160A. Introduction to Control Systems. 4 Units.
Modeling, stability, and specifications of feedback control systems. Root locus, Bode plots, Nyquist criteria, and state-space methods for dynamic analysis and design.

(Design units: 2)

Corequisite: EECS 160LA
Prerequisite: (EECS 10 or EECS 12 or MAE 10 or BME 60B or CEE 20) and EECS 150 and EECS 170B and EECS 170LB

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

EECS 160LA. Control Systems I Laboratory. 1 Unit.
Laboratory accompanying EECS 160A. Materials fee.

(Design units: 1)

Corequisite: EECS 160A

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

EECS 163. Power Systems. 4 Units.
Generation, transmission, and use of electrical energy. Fault calculation, protection, stability, and power flow.

(Design units: 1)

Corequisite: EECS 163L
Prerequisite: EECS 70B

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment.

EECS 163L. Power Systems Laboratory. 1 Unit.
Experiments and field trips relevant to studies in power systems. Materials fee.

(Design units: 0)

Corequisite: EECS 163

Restriction: Computer Science Engineering Majors only. Electrical Engineering Majors only. Computer Engineering Majors only.

EECS 166A. Industrial and Power Electronics. 4 Units.
Power switching devices, pulse width modulation (PWM) methods, switching converter topologies, control, and magnetics. Materials fee.

(Design units: 2)

Prerequisite: EECS 170C and EECS 160A

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have second consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

Concurrent with EECS 267A.

EECS 170A. Electronics I. 4 Units.
The properties of semiconductors, electronic conduction in solids, the physics and operation principles of semiconductor devices such as diodes and transistors, transistor equivalent circuits, and transistor amplifiers.

(Design units: 1)

Corequisite: PHYS 7E
Prerequisite: PHYS 7D and EECS 70B

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

EECS 170B. Electronics II. 4 Units.
Design and analysis of single-stage amplifiers, biasing circuits, inverters, logic gates, and memory elements based on CMOS transistors.

(Design units: 2)

Corequisite: EECS 170LB
Prerequisite: EECS 70B and EECS 170A and EECS 170LA

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

EECS 170C. Electronics III. 4 Units.
Principles of operation, design, and utilization of integrated circuit modules, including multi-stage amplifiers, operational amplifiers, and logic circuits.

(Design units: 2)

Corequisite: EECS 170LC
Prerequisite: EECS 170B and EECS 170LB

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have second consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

EECS 170D. Integrated Electronic Circuit Design. 4 Units.
Design and fabrication of modern digital integrated circuits. Fabrication of CMOS process, transistor-level design simulation, functional characteristics of basic digital integrated circuits, and different logic families including the static and dynamic logic, layout, and extraction of digital circuits.

(Design units: 4)

Prerequisite: EECS 170C and EECS 170LC

Overlaps with EECS 119, CSE 112.

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have second consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

EECS 170E. Analog and Communications IC Design. 4 Units.
Advanced topics in design of analog and communications integrated circuits. Topics include: implementation of passive components in integrated circuits; overview of frequency response of amplifiers, bandwidth estimation techniques, high-frequency amplifier design; design of radio-frequency oscillators.

(Design units: 3)

Prerequisite: EECS 170C

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have second consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

EECS 170LA. Electronics I Laboratory. 1 Unit.
Laboratory accompanying EECS 170A to perform experiments on semiconductor material properties, semiconductor device physics and operation principles, and transistor amplifiers to improve experimental skills and to enhance the understanding of lecture materials.

(Design units: 1)

Corequisite: EECS 170A and PHYS 7E
Prerequisite: PHYS 7D and EECS 70B

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment.

EECS 170LB. Electronics II Laboratory. 1 Unit.
Laboratory accompanying EECS 170B.

(Design units: 1)

Corequisite: EECS 170B
Prerequisite: EECS 170A and EECS 170LA

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

EECS 170LC. Electronics III Laboratory. 1 Unit.
Laboratory accompanying EECS 170C to provide hands-on training in design of digital/analog circuits/subsystems. Materials fee.

(Design units: 1)

Corequisite: EECS 170C
Prerequisite: EECS 170B and EECS 170LB

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Engineering Majors have second consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

EECS 174. Semiconductor Devices. 4 Units.
Metal-semiconductor junctions, diodes, bipolar junction transistors, MOS structures, MOSFETs, CMOS technology, LEDs, and laser diodes.

(Design units: 1)

Prerequisite: EECS 170A

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment. Materials Science Engineering Majors have second consideration for enrollment.

EECS 176. Fundamentals of Solid-State Electronics and Materials. 4 Units.
Physical properties of semiconductors and the roles materials play in device operation. Topics include: crystal structure, phonon vibrations, energy band, transport phenomenon, optical properties and quantum confinement effect essential to the understanding of electronic, optoelectronic and nanodevices.

(Design units: 1)

Prerequisite: EECS 170A

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment.

EECS 179. Microelectromechanical Systems (MEMS). 4 Units.
Small-scale machines, small-scale phenomena, MEMS fabrication, MEMS CAD tools, MEMS devices and packaging, MEMS testing.

(Design units: 2)

Restriction: Upper-division students only. Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment.

EECS 180A. Engineering Electromagnetics I. 4 Units.
Electrostatics, magnetostatics, and electromagnetic fields: solutions to problems in engineering applications; transmission lines, Maxwell's equations and phasors, plane wave propagation, reflection, and transmission.

(Design units: 1)

Prerequisite: PHYS 7E and EECS 145

Restriction: Electrical Engineering Majors have first consideration for enrollment. Biomedical Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

EECS 180B. Engineering Electromagnetics II. 4 Units.
Time-varying electromagnetic fields, plane waves, polarization, guidance of waves like rectangular waveguides and microstrips, optical fibers resonant cavities, skin effects and losses, spherical waves, radiation and reception of waves, antenna basics.

(Design units: 1)

Prerequisite: EECS 180A

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

EECS 182. Monolithic Microwave Integrated Circuit (MMIC) Analysis and Design. 4 Units.
Design of microwave amplifiers including low-noise amplifiers, multiple stage amplifiers, power amplifiers, and introduction to broadband amplifiers. The goal is to provide the basic knowledge for the design of microwave amplifiers ranging from wireless system to radar system.

(Design units: 3)

Prerequisite: EECS 180A

Restriction: Computer Science Engineering Majors have first consideration for enrollment. Electrical Engineering Majors have first consideration for enrollment.

EECS 188. Optical Electronics. 4 Units.
Photodiodes and optical detection, photometry and radiometry, geometric optics, lens theory, imaging system, EM wave propagation, optical waveguides and fibers, heterojunction structures, laser theory, semiconductor lasers, and optical transmission system.

(Design units: 1)

Prerequisite: EECS 180A

Restriction: Electrical Engineering Majors have first consideration for enrollment. Computer Science Engineering Majors have second consideration for enrollment.

EECS 195. Special Topics in Electrical and Computer Engineering. 1-4 Units.
Studies special topics in selected areas of Electrical and Computer Engineering. Topics addressed vary each quarter.

(Design units: 1-4)

Prerequisite: Prerequisites vary.

Repeatability: Unlimited as topics vary.

EECS 197. Electrical Engineering and Computer Science Internship. 2-12 Units.
Students majoring in EECS may receive credit for an approved internship, working at a company under the supervision of an industry mentor and a faculty advisor. Enables students to gain valuable experience in a professional setting and enhance their skills.

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit 3 times.

EECS 198. Group Study. 1-4 Units.
Group study of selected topics in Electrical and Computer Engineering.

(Design units: 1-4)

Repeatability: May be repeated for credit unlimited times.

Restriction: Upper-division students only.

EECS 199. Individual Study. 1-4 Units.
For undergraduate Engineering majors in supervised but independent reading, research, or design. Students taking Individual study for design credit are to submit a written paper to the instructor and to the Undergraduate Student Affairs Office in the School of Engineering.

(Design units: 1-4)

Repeatability: May be taken for credit for 8 units.

EECS 199P. Individual Study. 1-4 Units.
For undergraduate Engineering majors in supervised but independent reading, research, or design. Students taking individual study for design credit are to submit a written paper to the instructor and to the Student Affairs Office in the School of Engineering.

(Design units: 1-4)

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

EECS 202P. Techniques in Medical Imaging: X-ray, Nuclear, and NMR Imaging. 4 Units.
Ionizing radiation, planar and tomographic radiographic and nuclear imaging, magnetism, NMR, MRI imaging.

Restriction: Master of Engineering students only. Graduate students only.

EECS 203A. Digital Image Processing. 4 Units.
Pixel-level digital image representation and elementary operations; Fourier and other unitary transforms; compression, enhancement, filtering, and restoration; laboratory experience is provided.

Restriction: Graduate students only.

EECS 203P. Digital Image Processing. 4 Units.
Pixel-level digital image representation and elementary operations; Fourier and other unitary transforms; compression, enhancement, filtering, and restoration; laboratory experience is provided.

Restriction: Master of Engineering students only. Graduate students only.

EECS 204P. Personalized Medical Devices. 4 Units.
Introduces students to fundamental aspects of medical devices and discusses therapeutic as well as diagnostic devices. Basic aspects of microfluidics and biology critical to personalized medical systems are studied. Typical FDA approval pathways for medical devices are presented.

Same as MAE 204P.

Restriction: Master of Engineering students only.

Concurrent with BME 204P.

EECS 211. Advanced System Software. 4 Units.
Study of operating systems including interprocess communication, scheduling, resource management, concurrency, reliability, validation, protection and security, and distributed computing support. System software design languages and modeling analysis.

Restriction: Graduate students only.

EECS 211P. Advanced System Software. 4 Units.
Study of operating systems including interprocess communication, scheduling, resource management, concurrency, reliability, validation, protection and security, and distributed computing support. System software design languages and modeling analysis.

Prerequisite: Recommended: Undergraduate-level knowledge of system software (e.g. EECS 111) and organization of digital computers (e.g. UCI EECS 112).

Restriction: Master of Engineering students only. Graduate students only.

EECS 213. Computer Architecture. 4 Units.
Problems in hardware, firmware (microprogram), and software. Computer architecture for resource sharing, real-time applications, parallelism, microprogramming, and fault tolerance. Various architectures based on cost/performance and current technology.

Restriction: Graduate students only.

EECS 213P. Computer Architecture. 4 Units.
Problems in hardware, firmware (microprogram), and software. Computer architecture for resource sharing, real-time applications, parallelism, microprogramming, and fault tolerance. Various architectures based on cost/performance and current technology.

Prerequisite: Recommended: Undergraduate-level knowledge of organization of digital computers (e.g. EECS 112 and EECS 112L).

Restriction: Master of Engineering students only. Graduate students only.

EECS 215. Design and Analysis of Algorithms. 4 Units.
Computer algorithms from a practical standpoint. Algorithms for symbolic and numeric problems such as sorting, searching, graphs, and network flow. Analysis includes algorithm time and space complexity.

EECS 215P. Design and Analysis of Algorithms. 4 Units.
Computer algorithms from a practical standpoint. Algorithms for symbolic and numeric problems such as sorting, searching, graphs, and network flow. Analysis includes algorithm time and space complexity.

Restriction: Master of Engineering students only. Graduate students only.

EECS 216. Advanced Application of Algorithms. 4 Units.
Medium-sized group and individual programming project. Topics include specification requirements documentation, practical implementation of algorithms, and testing/verification of design.

Prerequisite: Recommended: Undergraduate course work in engineering data structures and algorithms.

EECS 217. VLSI System Design. 4 Units.
Overview of integrated fabrication, circuit simulation, basic device physics, device layout, timing; MOS logic design; layout generation, module generation, techniques for very large scale integrated circuit design.

Restriction: Graduate students only.

EECS 217P. VLSI System Design. 4 Units.
Overview of integrated fabrication, circuit simulation, basic device physics, device layout, timing; MOS logic design; layout generation, module generation, techniques for very large scale integrated circuit design.

Prerequisite: Recommended: Undergraduate-level knowledge of organization of digital computers (e.g. EECS 112).

Restriction: Master of Engineering students only. Graduate students only.

EECS 220P. Advanced Digital Signal Processing Architecture. 4 Units.
Study the latest DSP architectures for applications in communication (wired and wireless) and multimedia processing. Emphasis given to understanding the current design techniques and to evaluate the performance, power, and application domain of the latest DSP processors.

Prerequisite: EECS 213P. EECS 213P with a grade of B- or better

Restriction: Graduate students only. Master of Engineering students only.

EECS 221. Topics in Computer Engineering. 4 Units.
New research results in computer engineering.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

EECS 222. Embedded System Modeling. 4 Units.
Computational models for embedded systems. System-level specification and description languages. Concepts, requirements, examples. Embedded system models at different levels of abstraction. Modeling of test benches, design under test, IP components. Discrete event simulation, semantics, and algorithms. Formerly EECS 222A.

Restriction: Graduate students only.

EECS 223. Real-Time Computer Systems. 4 Units.
Time bases, clock synchronization, real-time communication protocols, specification of requirements, task scheduling. Validation of timelines, real-time configuration management.

Prerequisite: EECS 211 and EECS 213. EECS 211 with a grade of B- or better. EECS 213 with a grade of B- or better

Restriction: Graduate students only.

EECS 223P. Real-Time Computer Systems. 4 Units.
Time bases, clock synchronization, real-time communication protocols, specification of requirements, task scheduling. Validation of timelines, real-time configuration management.

Prerequisite: EECS 211P and EECS 213P. EECS 211P with a grade of B- or better. EECS 213P with a grade of B- or better

Restriction: Graduate students only. Master of Engineering students only.

EECS 224. High-Performance Computing. 4 Units.
Fundamentals of high-performance computing, covering both theory and practice. Topics include performance analysis and tuning, design of parallel and I/O efficient algorithms, basics of parallel machine architectures, and current/emerging programming models (shared memory, distributed memory, and accelerators).

Prerequisite: EECS 215 or CS 260. EECS 215 with a grade of B- or better. CS 260 with a grade of B- or better

Restriction: Graduate students only.

EECS 226. Embedded System Software. 4 Units.
Embedded system software concepts, requirements, examples, for engineering applications such as multi-media and automotive. Software generation methodology. Algorithmic specification, design constraints. Embedded operating systems. Static, dynamic, real-time scheduling. Input/output, interrupt handling. Code generation, compilation, instruction set simulation. Formerly EECS 222C.

Restriction: Graduate students only.

EECS 227. Cyber-Physical System Design. 4 Units.
Model-based design of cyber-physical systems including, e.g., plant, sensing, control, actuation, embedded hardware/software, communication, real-time analysis, various levels of simulation (MILS, SILS, HILS), tools and methodologies for automatic synthesis, and application from various interdisciplinary domains.

Restriction: Graduate students only.

EECS 230. Energy Efficiency. 4 Units.
Green energy sources for production, transmission, storage, and utilization of electricity, with a special focus on solar, wind, and nuclear energy production. Study of newly developed renewable sources of energy including capital cost, product cost, environmental issues, and technical feasibility.

EECS 230P. Introduction to Machine Learning. 4 Units.
Introduces fundamental concepts in programming and machine learning. The goal is to provide an accessible introduction to the field of machine learning and related techniques for students with a wide variety of engineering degrees.

Same as BME 230P, CEE 230P, ENGR 230P, MAE 230P.

Restriction: Master of Engineering students only.

EECS 231. Advanced System Security. 4 Units.
Advanced study about system security. Topics include software vulnerabilities (buffer overflow), vulnerability discovery (fuzzing), network security, side-channel analysis (power analysis and micro-architecture attacks), machine-learning security, IoT security, and privacy (differential privacy).

Restriction: Graduate students only.

EECS 232. Data Privacy. 4 Units.
Presents data privacy in the digital age from multiple perspectives, including theoretical frameworks for privacy; tracking practices and privacy-enhancing technologies in various application domains; and data protection laws and policy.

Prerequisite: Recommended: Students should have familiarity with networking (web/HTTP, DNS, mobile devices) (EECS 148 or equivalent), probability (EECS 55 or equivalent), and programming in python (EECS 12 or equivalent) at the undergraduate level.

Restriction: Graduate students only.

EECS 240. Random Processes. 4 Units.
Extensions of probability theory to random variables varying with time. General properties of stochastic processes. Convergence. Estimation, including nonlinear and linear minimum mean square error and maximum likelihood. Spectral density and linear filters. Poisson processes and discrete-time Markov chains.

Restriction: Graduate students only.

EECS 240P. Random Processes. 4 Units.
Extensions of probability theory to random variables varying with time. General properties of stochastic processes. Convergence. Estimation, including nonlinear and linear minimum mean square error and maximum likelihood. Spectral density and linear filters. Poisson processes and discrete-time Markov chains.

Prerequisite: Recommended: Knowledge of engineering probability (e.g. EECS 55).

Restriction: Master of Engineering students only. Graduate students only.

EECS 241A. Digital Communications I. 4 Units.
Concepts and applications of digital communication systems. Baseband digital transmission of binary, multiamplitude, and multidimensional signals. Introduction to and performance analysis of different modulation schemes.

EECS 241AP. Digital Communications I. 4 Units.
Concepts and applications of digital communication systems. Baseband digital transmission of binary, multiamplitude, and multidimensional signals. Introduction to and performance analysis of different modulation schemes.

Restriction: Master of Engineering students only. Graduate students only.

EECS 241B. Digital Communications II. 4 Units.
Concepts and applications of equalization, multi-carrier modulation, spread spectrum and CDMA. Digital communications through fading memory channels.

Prerequisite: EECS 241A. EECS 241A with a grade of B- or better

Restriction: Graduate students only.

EECS 241BP. Digital Communications II. 4 Units.
Concepts and applications of equalization, multi-carrier modulation, spread spectrum, and CDMA. Digital communications through fading memory channels.

Prerequisite: EECS 241AP. EECS 241AP with a grade of B- or better

Restriction: Graduate students only. Master of Engineering students only.

EECS 242. Information Theory. 4 Units.
Fundamental capabilities and limitations of information sources and information transmission systems. Analytical framework for modeling and evaluating communication systems: entropy, mutual information asymptotic equipartition property, entropy rates of a stochastic process, data compression, channel capacity, differential entropy, the Gaussian channel.

Prerequisite: EECS 240. EECS 240 with a grade of B- or better

EECS 244. Wireless Communications. 4 Units.
Introduction to wireless communications systems. Wireless channel modeling. Single carries, spread spectrum, and multi-carrier wireless modulation schemes. Diversity techniques. Multiple-access schemes. Transceiver design and system level tradeoffs. Brief overview of GSM, CDMA, (IS-95) and 2.5, 3G cellular schemes.

Prerequisite: EECS 241B. EECS 241B with a grade of B- or better

Restriction: Graduate students only.

EECS 244P. Wireless Communications. 4 Units.
Introduction to wireless communications systems. Wireless channel modeling. Single carries, spread spectrum, and multi-carrier wireless modulation schemes. Diversity techniques. Multiple-access schemes. Transceiver design and system level tradeoffs. Brief overview of GSM, CDMA, (IS-95) and 2.5, 3G cellular schemes.

Prerequisite: EECS 241BP. EECS 241BP with a grade of B- or better

Restriction: Graduate students only. Master of Engineering students only.

EECS 247. Information Storage. 4 Units.
Storage architecture, storage network and networking algorithms in data centers, principle of storage devices and non-volatile memory, data consistency, data availability and integrity, power management.

Restriction: Graduate students only.

EECS 248A. Computer and Communication Networks. 4 Units.
Network architecture of the Internet, telephone networks, cable networks, and cell phone networks. Network performance models. Network performance models. Advanced concepts and implementations of flow and congestion control, addressing, internetworking, forwarding, routing, multiple access, streaming, and quality-of-service.

Prerequisite: EECS 148 or CS 132

Same as CS 232, NSYS 201.

Restriction: Graduate students only.

EECS 250. Digital Signal Processing I. 4 Units.
Fundamental principles of digital signal processing, sampling, decimation and interpolation, discrete Fourier transforms and FFT algorithms, transversal and recursive filters, discrete random processes, and finite-word effects in digital filters.

Restriction: Graduate students only.

EECS 250P. Digital Signal Processing I. 4 Units.
Fundamental principles of digital signal processing, sampling, decimation and interpolation, discrete Fourier transforms and FFT algorithms, transversal and recursive filters, discrete random processes, and finite-word effects in digital filters.

Prerequisite: Recommended: Knowledge of digital signal processing (e.g. EECS 152A).

Restriction: Master of Engineering students only. Graduate students only.

EECS 251A. Detection, Estimation, and Demodulation Theory. 4 Units.
Fundamentals of hypothesis testing and Bayes and Maximum Likelihood Estimation. ARMA and state variable models for random time series analysis. Wiener and Kalman filtering and prediction. Adaptive algorithms for identification and tracking of parameters of time-varying models.

Prerequisite: EECS 240. EECS 240 with a grade of B- or better

EECS 251B. Detection, Estimation, and Demodulation Theory. 4 Units.
Fundamentals of hypothesis testing and Bayes and Maximum Likelihood Estimation. ARMA and state variable models for random time series analysis. Wiener and Kalman filtering and prediction. Adaptive algorithms for identification and tracking of parameters of time-varying models.

Prerequisite: EECS 240. EECS 240 with a grade of B- or better

EECS 253. Machine Learning for Signal Processing. 4 Units.
Machine learning and computational neuroscience methods for signal processing. Theory and applications are described, as well as practical programming methods in Python using Keras and TensorFlow 2.

Prerequisite: Recommended: EECS 125 or equivalent undergraduate-level introduction to machine learning and EECS 152A or equivalent undergraduate course in digital signal processing. Knowledge of introductory linear algebra and differential equations, elementary probability theory, and elementary Python programming.

Restriction: Graduate students only.

EECS 254. Theory of Machine Learning. 4 Units.
The math background underlying machine learning algorithms and structures, including backpropagation, radial basis functions, deep belief nets, support vector machines, and dynamic programming. The relation of learning algorithms to estimation, recursive filtering, dimensionality reduction, and sequential optimization.

Prerequisite: Recommended: EECS 125 or equivalent undergraduate-level introduction to machine learning. Knowledge of introductory linear algebra and differential equations, elementary probability theory, and elementary Matlab programming.

Restriction: Graduate students only.

EECS 260A. Linear Systems I. 4 Units.
State-space representation of continuous-time and discrete-time linear systems. Controllability, observability, stability. Realization of rational transfer functions.

Restriction: Graduate students only.

EECS 261A. Linear Optimization Methods. 4 Units.
Formulation, solution, and analysis of linear programming and linear network flow problems. Simplex methods, dual ascent methods, interior point algorithms, and auction algorithms. Duality theory and sensitivity analysis. Shortest path, max-flow, assignment, and minimum cost flow problems.

Restriction: Graduate students only.

EECS 267A. Industrial and Power Electronics. 4 Units.
Power switching devices, pulse width modulation (PWM) methods, switching converter topologies, control, and magnetics. Materials fee.

Restriction: Graduate students only.

Concurrent with EECS 166A.

EECS 267B. Topics in Industrial and Power Electronics. 4 Units.
Practical design of switching converters, electromagnetic compatibility, thermal management, and/or control methods.

Prerequisite: EECS 267A. EECS 267A with a grade of B- or better

Restriction: Graduate students only.

EECS 270A. Advanced Analog Integrated Circuit Design I. 4 Units.
Basic transistor configurations; differential pairs; active load/current sources; supply/temperature-independent biasing; op-amp gain and output stages; amplifier frequency response and stability compensation; nonidealities in op-amps; noise and dynamic range in analog circuits.

Restriction: Graduate students only.

EECS 270AP. Advanced Analog Integrated Circuit Design I. 4 Units.
Basic transistor configurations; differential pairs; active load/current sources; supply/temperature-independent biasing; op-amp gain and output stages; amplifier frequency response and stability compensation; nonidealities in op-amps; noise and dynamic range in analog circuits.

Prerequisite: Recommended: Introductory knowledge of control systems (e.g. EECS 160A) and electronics (e.g. EECS 170C).

Restriction: Master of Engineering students only. Graduate students only.

EECS 270B. Advanced Analog Integrated Circuit Design II. 4 Units.
Advanced transistor modeling issues; discrete-time and continuous-time analog Integrated Circuit (IC) filters; phase-locked loops; design of ICs operating at radio frequencies; low-voltage/low-power design techniques; A/D and D/A converters; AGC circuits.

Prerequisite: EECS 270A. EECS 270A with a grade of B- or better

Restriction: Graduate students only.

EECS 270BP. Advanced Analog Integrated Circuit Design II. 4 Units.
Advanced transistor modeling issues; discrete-time and continuous-time analog Integrated Circuit (IC) filters; phase-locked loops; design of ICs operating at radio frequencies; low-voltage/low-power design techniques; A/D and D/A converters; AGC circuits.

Prerequisite: EECS 270AP. EECS 270AP with a grade of B- or better

Restriction: Graduate students only. Master of Engineering students only.

EECS 270C. Design of Integrated Circuits for Broadband Applications. 4 Units.
Topics include: broadband standards and protocols; high-frequency circuit design techniques; PLL theory and design; design of transceivers; electrical/optical interfaces.

Prerequisite: EECS 270A. EECS 270A with a grade of B- or better

Restriction: Graduate students only.

EECS 270D. Radio-Frequency Integrated Circuits and Systems. 4 Units.
Fundamental topics in radio-frequency (RF) integrated circuits and systems including basic concepts in RF circuits and systems, RF receiver and transmitter architectures, and RF core building blocks such as low-noise amplifiers (LNAs), RF mixers, and power amplifiers.

Prerequisite: EECS 270A. EECS 270A with a grade of B- or better

Restriction: Graduate students only.

EECS 270E. MM-Wave and Terahertz Circuits. 4 Units.
Discussion of the new methodologies, circuits, and systems developed at mm-wave and terahertz frequency ranges due to the growing interest in high speed communication and high frequency signal generation.

Restriction: Graduate students only.

EECS 272P. Radio-Frequency Integrated Circuit Design. 4 Units.
Topics include RF component modeling; matching network design; transmission line theory/modeling; Smith chart and S-parameters; noise modeling of active and passive components; high-frequency amplifier design; low-noise amplifier (LNA) design; mixer design; RF power amplifier.

Prerequisite: EECS 270AP. EECS 270AP with a grade of B or better

Restriction: Master of Engineering students only. Graduate students only.

EECS 277A. Advanced Semiconductor Devices I. 4 Units.
Advanced complementary metal-oxide-semiconductor field-effect transistors (CMOSFET), device scaling, device modeling and fabrication, equivalent circuits, and their applications for digital, analog, RF.

Restriction: Graduate students only.

EECS 277B. Advanced Semiconductor Devices II. 4 Units.
Metal-semiconductor field-effect transistors (MESFET), heterojunction bipolar transistors (HBT), microwave semiconductor devices, equivalent circuits, device modeling and fabrication, microwave amplifiers, transmitters, and receivers.

Restriction: Graduate students only.

EECS 277C. Nanotechnology. 4 Units.
Fabrication and characterization techniques of electrical circuit elements at the nanometer scale. Quantized conductance, semiconductor quantum dots, single electron transistors, molecular wires, carbon nanotubes, self-assembly of nano-circuit elements, quantum methods of information processing.

Restriction: Graduate students only.

EECS 278. Micro-System Design. 4 Units.
Covers the fundamentals of the many disciplines needed for design of Micro-Electro-Mechanical Systems (MEMS): microfabrication technology, structural mechanics on micro-scale, electrostatics, circuit interface, control, computer-aided design, and system integration.

Same as MAE 247.

Restriction: Graduate students only.

EECS 279. Micro-Sensors and Actuators. 4 Units.
Introduction to the technology of Micro-Electro-Mechanical Systems (MEMS). Fundamental principles and applications of important microsensors, actuation principles on microscale. Introduction to the elements of signal processing; processing of materials for micro sensor/actuator fabrication; smart sensors and microsensor/microactuator array devices.

Same as MAE 249.

Restriction: Graduate students only.

EECS 280A. Advanced Engineering Electromagnetics I. 4 Units.
Stationary electromagnetic fields, Maxwell's equations, circuits and transmission lines, plane waves, guided waves, and radiation.

Restriction: Graduate students only.

EECS 280B. Advanced Engineering Electromagnetics II. 4 Units.
Two- and three-dimensional boundary value problems, dielectric waveguides and other special waveguides, microwave networks and antenna arrays, electromagnetic properties of materials, and electromagnetic optics.

Prerequisite: EECS 280A. EECS 280A with a grade of B- or better

Restriction: Graduate students only.

EECS 280P. Advanced Engineering Electromagnetics I. 4 Units.
Stationary electromagnetic fields, Maxwell's equations, circuits and transmission lines, plane waves, guided waves, and radiation.

Prerequisite: Recommended: Knowledge of engineering electromagnetics (e.g. EECS 180A).

Restriction: Master of Engineering students only. Graduate students only.

EECS 282. Monolithic Microwave Integrated Circuit (MMIC) Analysis and Design II. 4 Units.
Design of microwave amplifiers using computer-aided design tools. Covers low-noise amplifiers, multiple stage amplifiers, broadband amplifiers, and power amplifiers. Hybrid circuit design techniques including filters and baluns. Theory and design rules for microwave oscillator design.

Restriction: Graduate students only.

EECS 284. Wireless Communication Links and Antenna Design. 4 Units.
Provides the fundamental understanding of the electromagnetic part of wireless communication links and their antennas, i.e., their key components. Contains hands-on component where students learn how to use the best CADs used in industry and academia.

Prerequisite: Recommended: EECS 180A

Concurrent with EECS 184.

EECS 284P. RF Antenna Design . 4 Units.
Advanced transmission line design, radiation of electromagnetic waves, dipole antennas, antenna arrays, advanced antenna designs, and practical design considerations in communications systems. Course is supplemented by RF design tools and modeling.

Prerequisite: EECS 280AP. EECS 280AP with a grade of B- or better

Restriction: Graduate students only. Master of Engineering students only.

EECS 285A. Optical Communications. 4 Units.
Introduction to fiber optic communication systems, optical and electro-optic materials, and high-speed optical modulation and switching devices.

Restriction: Graduate students only.

EECS 285B. Lasers and Photonics. 4 Units.
Covers the fundamentals of lasers and applications, including Gaussian beam propagation, interaction of optical radiation with matters, and concepts of optical gain and feedback. Applications are drawn from diverse fields of optical communication, signal processing, and material diagnosis.

Prerequisite: Undergraduate course work in electromagnetic theory and atomic physics.

EECS 285C. Nano Imaging. 4 Units.
Theory and practice of modern nanoscale imaging techniques and applications. Traces the development of microscopy from ancient times to modern day techniques used for visualizing the nano-world from atoms to molecules including hands-on experience in the laboratory.

Restriction: Graduate students only.

EECS 285P. Optical Communications. 4 Units.
Introduction to fiber optic communication systems, optical and electro-optic materials, and high-speed optical modulation and switching devices.

Prerequisite: Undergraduate-level Engineering Electromagnetics I (e.g. EECS E80A).

Restriction: Master of Engineering students only. Graduate students only.

EECS 286. Fabrication of Biomedical and Wearable Microdevices. 4 Units.
Covers preliminary details on prototyping and fabrication techniques for biomedical and wearable microdevices. Fabrication and behavior of modern biomed device materials such as hydrogel, PDMS, biopolymer, smart materials, and their uses are introduced.

Prerequisite: Required: Knowledge of undergraduate-level basic physics.

Restriction: Graduate students only.

EECS 287. Micro/Nano Biotechnology and Biosensing: Fundamentals, Designs, and Applications. 4 Units.
Provides insight into the current topics in Micro/Nanoscience, Micro/Nanotechnology fundamentals, and their modern-day applications in life sciences. Focus is on Micro/Nanodevices; Sensors' fundamentals; NanoBioSensors; Microfluidics; Micro/Nanofabrication, detection system-level characterization; performance determination; solid-state materials; and more.

Restriction: Graduate students only.

EECS 289. Bioinstrumentation. 4 Units.
Introduces instrumentation used in biomedical research, clinical medicine, and health monitoring. Interfacing of bioelectronics and biomedical sensing are taught with the most updated methods. The integration of bioinstrumentation with data science and cloud computing are introduced.

Restriction: Graduate students only.

EECS 292. Preparation for M.S. Comprehensive Examination. 1-8 Units.
Individual reading and preparation for the M.S. comprehensive examination.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

EECS 293. Preparation for Ph.D. Preliminary Examination. 1-8 Units.
Individual reading and preparation for the Ph.D. preliminary examination.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

EECS 294. Electrical Engineering and Computer Science Colloquium. 1 Unit.
Invited speakers discuss their latest research results in electrical engineering and computer science.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

EECS 295. Seminars in Engineering. 1-4 Units.
Scheduled each year by individual faculty in major field of interest.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

EECS 295P. Special Topics in Electrical Engineering and Computer Science. 4 Units.
Studies in selected areas of Electrical Engineering. Topics addressed vary each quarter.

Repeatability: Unlimited as topics vary.

Restriction: Master of Engineering students only. Graduate students only.

EECS 296. Master of Science Thesis Research. 1-16 Units.
Individual research or investigation conducted in the pursuit of preparing and completing the thesis required for the M.S. degree in Engineering.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

EECS 297. Doctor of Philosophy Dissertation Research. 1-16 Units.
Individual research or investigation conducted in preparing and completing the dissertation required for the Ph.D. degree in Engineering.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

EECS 298. Topics in Electrical Engineering and Computer Science. 4 Units.
Study of Electrical and Computer Engineering concepts.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

EECS 299. Individual Research. 1-16 Units.
Individual research or investigation under the direction of an individual faculty member.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.