

a California teaching credential. Interested students should consult the credential advisor in the Graduate School of Education.

Under the direction of the Associate Dean for Undergraduate Studies, academic advising services are jointly provided by advisors in the College of Engineering, as well as advisors in the department. Students who plan to change to a major in the department should consult the ECE student office. Departmental faculty advisors are assigned to students to assist them in choosing senior elective courses.

Counseling is provided to graduate students through the ECE graduate advisor. Individual faculty members are also available for help in academic planning.

Mission Statement

The Department of Electrical and Computer Engineering seeks to provide a comprehensive, rigorous and accredited educational program for the graduates of California's high schools and for postgraduate students, both domestic and international. The department has a dual mission:

- **Education:** We will develop and produce excellent electrical and computer engineers who will support the high-tech economy of California and the nation. This mission requires that we offer a balanced and timely education that includes not only strength in the fundamental principles but also experience with the practical skills that are needed to contribute to the complex technological infrastructure of our society. This approach will enable each of our graduates to continue learning throughout an extended career.
- **Research:** We will develop relevant and innovative science and technology through our research that addresses the needs of industry, government and the scientific community. This technology can be transferred through our graduates, through industrial affiliations, and through publications and presentations.

We provide a faculty that is committed to education and research, is accessible to students, and is highly qualified in their areas of expertise.

Educational Objectives

The educational objectives of the Electrical Engineering Program identify what we hope that our graduates will accomplish within a few years after graduation.

1. We expect our graduates to make positive contributions to society in fields including, but not limited to, engineering.
2. We expect our graduates to have acquired the ability to be flexible and adaptable, showing that their educational background has given them the foundation needed to remain effective, take on new responsibilities and assume leadership roles.
3. We expect some of our graduates to pursue their formal education further, including graduate study for master's and doctoral degrees.

Program Outcomes

The EE program expects our students upon graduation to have:

1. Acquired strong basic knowledge and skills in those fundamental areas of mathematics, science, and electrical engineering that are required to support specialized professional training at the advanced level and to provide necessary breadth to the student's overall program of studies. This provides the basis for lifelong learning.
2. Experienced in-depth training in state-of-the-art specialty areas in electrical engineering. This is implemented through our senior electives. Students are required to take two sequences of at least two courses each at the senior level.
3. Benefited from imaginative and highly supportive laboratory experiences where appropriate throughout the program. The laboratory experience will be closely integrated with coursework and will make use of up-to-date instrumentation and computing facilities. Students should experience both hardware-oriented and simulation-oriented exercises.
4. Experienced design-oriented challenges that exercise and integrate skills and knowledge acquired in several courses. These may include design of components or subsystems with performance specifications. Graduates should be able to demonstrate an ability to design and conduct experiments as well as analyze the results.
5. Learned to function well in teams. Also, students must develop communication skills, written and oral, both through team and classroom experiences. Skills including written reports, webpage preparation, and public presentations are required.
6. Completed a well-rounded and balanced education through required studies in selected areas of fine arts, humanities, and social sciences. This provides for the ability to understand the impact of engineering solutions in a global and societal context. A course in engineering ethics is also required of all undergraduates.

Undergraduate Program

Bachelor of Science—Electrical Engineering

A minimum of 194 units is required for graduation. A complete list of requirements for the major can be found on page 48. Schedules should be planned to meet both General Education and major requirements.

The department academic advisor can suggest a recommended study plan for electrical engineering freshmen and sophomores. Each student is assigned a departmental faculty advisor who must be

consulted in planning the junior and senior year programs.

The required 32 units (8 courses) of departmental electives are taken primarily in the senior year, and they permit students to develop depth in specialty areas of their choice. A student's elective course program must be approved by a departmental faculty advisor. The advisor will check the program to ensure satisfaction of the departmental requirements. A wide variety of elective programs will be considered acceptable.

Three matters should be noted: (1) students who fail to attain a grade-point average of at least 2.0 in the major may be denied the privilege of continuing in the major, (2) a large majority of electrical and computer engineering courses have prerequisites which must be completed successfully. Successful completion of prerequisite courses means receiving a grade of C- or better in prerequisite courses except for Mathematics 3A-B-C and Mathematics 5A and 5B which require a grade of C or better to apply these courses as prerequisites, (3) courses required for the pre-major or major, inside or outside of the Department of Electrical Engineering, cannot be taken for the passed/not passed grading option. They must be taken for letter grades.

Bachelor of Science—Computer Engineering

This major is offered jointly by the Department of Computer Science and the Department of Electrical and Computer Engineering. For information about this major, see page 22.

Electrical & Computer Engineering Courses

Many of the ECE courses are restricted to ECE majors only. Instructor and quarter offered are subject to change.

LOWER DIVISION

1. Ten Puzzling Problems in Computer Engineering

(1) PARHAMI

Prerequisite: open to pre-computer engineering only. Seminar, 1 hour.

Gaining familiarity with, and motivation to study, the field of computer engineering, through puzzle-like problems that represent a range of challenges facing computer engineers in their daily problem-solving efforts and at the frontiers of research.

2A. Circuits, Devices, and Systems

(5) YORK

Prerequisites: Mathematics 3A-B-C with a minimum grade of C; and, Mathematics 5A with a minimum grade of C (may be taken concurrently); Physics 3 or 23 (may be taken concurrently); open to electrical engineering, computer engineering, and pre-computer engineering majors only. Lecture, 3 hours; laboratory, 4 hours.

Introduction to basic circuit analysis. KCL, KVL, nodal analysis, superposition, independent and dependent sources; diodes and I-V characteristics; basic op-amp circuits; first-order transient analysis; AC analysis and phasors. Introduction to the use of test instruments.

2B. Circuits, Devices, and Systems

(5) YORK

Prerequisites: ECE 2A with a grade of C- or better; open to electrical engineering, computer engineering, and pre-computer engineering majors only. *Lecture, 3 hours; laboratory, 4 hours.*

Second order circuits. Laplace transform and solution of steady state and transient circuit problems in the s-domain; Bode plots; Fourier series and transforms; filters. Transistor as a switch; load lines; simple logic gates; latches and flip-flops.

2C. Circuits, Devices, and Systems

(5) YORK

Prerequisites: ECE 2B with a grade of C- or better (may be taken concurrently); open to electrical engineering, computer engineering, and pre-computer engineering majors only. *Lecture, 3 hours; laboratory, 4 hours.*

Two-port network parameters; small-signal models of nonlinear devices; transistor amplifier circuits; frequency response of amplifiers; non-ideal op-amps; modulation, bandwidth, signals; Fourier analysis.

4. Design Project for Freshmen

(4) STAFF

Prerequisites: Mathematics 3A-B-C and Physics 1 with minimum grades of C; Engineering 3 with a minimum grade of C-. *Lecture, 3 hours; laboratory, 3 hours.*

This first course on design gives an intuitive introduction to engineering design. Learn how to take an idea of a system and convert it to a working model. Use hardware and software for building a system.

15A. Fundamentals of Logic Design

(4) MAREK-SADOWSKA

Prerequisites: ECE 2A with a minimum grade of C-; open to electrical engineering, computer engineering, and pre-computer engineering majors only.

Not open for credit to students who have completed ECE 15. Lecture, 3 hours; discussion, 1 hour.

Boolean algebra, logic of propositions, minterm and maxterm expansions, Karnaugh maps, Quine-McCluskey methods, multi-level circuits, combinational circuit design and simulation, multiplexers, decoders, programmable logic devices.

15B. Computer Organization

(3) STAFF

Prerequisites: ECE 15A with a minimum grade of C-; open to electrical engineering, computer engineering, and pre-computer engineering majors only.

Not open for credit to students who have completed Computer Science 30 or ECE 15. Lecture, 3 hours; discussion, 1 hour.

Basic memory and processor organization, instruction set architecture, assembly language programming, number systems, arithmetic, data transfer and control flow instructions, procedures, memory management, program execution.

94AA-ZZ. Group Studies in Electrical and Computer Engineering

(1-4) STAFF

Prerequisite: consent of instructor.

Group studies intended for small number of advanced students who share an interest in a topic not included in the regular departmental curriculum.

UPPER DIVISION**121A. The Practice of Science**

(3) HU, AWSCHALOM

Prerequisite: Consent of instructor. Same course as Physics 121A.

Provides experience in pursuing careers within science and engineering through discussions with researchers, lectures on ethics, funding, intellectual property, and commercial innovation. Students prepare a focused research proposal that is pursued in the second quarter of the course.

121B. The Practice of Science

(4) HU, AWSCHALOM

Prerequisite: ECE 121A or Physics 121A; consent of instructor.

Same course as Physics 121B.

Provides experience in pursuing careers within science and engineering through discussions with researchers, lectures on ethics, funding, intellectual property, and commercial innovation. Students prepare a focused research proposal that is pursued in the second quarter of the course.

123. High-Performance Digital Circuit Design

(4) THEOGARAJAN

Prerequisite: ECE 2A-B-C with a minimum grade of C- in each of those courses; open to both electrical engineering and computer engineering majors only.

Introduction to high-performance digital circuit design techniques. Basics of device physics including deep submicron effects; device sizing and logical effort; Circuit design styles; clocking & timing issues; memory & datapath design; Low-power design; VLSI design flows and associated EDA tools

124A. VLSI Principles

(4) BANERJEE

Prerequisites: ECE 132 (may be taken concurrently) and ECE 152A with a minimum grade of C- in both. *Lecture, 3 hours; laboratory, 3 hours.*

Introduction to CMOS digital VLSI design: CMOS devices and manufacturing technology; transistor level design of static and dynamic logic gates and components and interconnections; circuit characterization: delay, noise margins, and power dissipation; combinational and sequential circuits; arithmetic operations and memories.

124B. Integrated Circuit Design and Fabrication

(4) BOWERS

Prerequisite: ECE 132 with a minimum grade of C-. *Lecture, 4 hours; laboratory, 3 hours.*

Theory, fabrication, and characterization of solid state devices including P-N junctions, capacitors, bipolar and MOS devices. Devices are fabricated using modern VLSI processing techniques including lithography, oxidation, diffusion, and evaporation. Physics and performance of processing steps are discussed and analyzed.

124C. Integrated Circuit Design and Fabrication

(4) BOWERS

Prerequisites: ECE 124B and ECE 137A with a minimum grade of C- in all. *Lecture, 4 hours; laboratory, 3 hours.*

Design, simulation, fabrication, and characterization of NMOS integrated circuits. Circuit design and layout is performed using commercial layout software. Circuits are fabricated using modern VLSI processing techniques. Circuit and discrete device electrical performance are analyzed.

124D. VLSI Architecture and Design

(4) BREWER

Prerequisite: ECE 124A with a minimum grade of C-. *Lecture, 3 hours; laboratory, 2 hours.*

Practical issues in VLSI circuit design, pad/pin limitations, clocking and interfacing standards, electrical packaging for high-speed and high-performance design. On-chip noise and crosstalk, clock and power distribution, architectural and circuit design constraints, interconnection limits and transmission line effects.

125. High Speed Digital Integrated Circuit Design

(4) BANERJEE

Prerequisite: ECE 124A or 137A with a minimum grade of C- in either. *Lecture, 4 hours.*

Advanced digital VLSI design: CMOS scaling, nanoscale issues including variability, thermal management, interconnects, reliability; non-clocked, clocked and self-timed logic gates; clocked storage elements; high-speed components, PLLs and DLLs; clock and power distribution; memory systems; signaling and I/O design; low-power design.

130A. Signal Analysis and Processing

(4) MADHOW

Prerequisites: Mathematics 5A and ECE 2B with

a minimum grade of C- in both; open to EE and computer engineering majors only. *Lecture, 3 hours; discussion, 2 hours.*

Analysis of continuous time linear systems in the time and frequency domains. Superposition and convolution. Bilateral and unilateral Laplace transforms. Fourier series and Fourier transforms. Filtering, modulation, and feedback.

130B. Signal Analysis and Processing

(4) CHANDRASEKARAN

Prerequisite: ECE 130A with a grade of C- or better; open to EE and computer engineering majors only. *Lecture, 3 hours; discussion, 2 hours.*

Analysis of discrete time linear systems in the time and frequency domains. Z transforms, Discrete Fourier transforms. Sampling and aliasing.

130C. Signal Analysis and Processing

(4) CHANDRASEKARAN

Prerequisites: ECE 130A-B with a minimum grade of C- in both. *Lecture, 3 hours; discussion, 2 hours.*

Basic techniques for the analysis of linear models in electrical engineering: Gaussian elimination, vector spaces and linear equations, orthogonality, determinants, eigenvalues and eigenvectors, systems of linear differential equations, positive definite matrices, singular value decomposition.

132. Introduction to Solid State Electronic Devices

(4) MISHRA

Prerequisites: Physics 4 or 24 with a minimum grade of C-; Mathematics 5A with a minimum grade of C; and ECE 2A-B (may be taken concurrently) with a minimum grade of C- in both; open to EE and computer engineering majors only. *Lecture, 3 hours; discussion, 2 hours.*

Electrons and holes in semiconductors; doping (P and N); state occupation statistics, transport properties of electrons and holes; P-N junction diodes; I-V, C-V, and switching properties of P-N junctions; introduction of bipolar transistors, MOSFET's and JFET's.

134. Introduction to Fields and Waves

(4) DAGLI, YORK

Prerequisites: Physics 3 or 23 with a minimum grade of C-; and Mathematics 5A-B with a minimum grade of C; and Mathematics 5C with a minimum grade of C-; open to EE and computer engineering majors only. *Lecture, 3 hours; discussion, 2 hours.*

Introduction to applied electromagnetics and wave phenomena in high frequency electron circuits and systems. Wave on transmission-lines, elements of electrostatics and magnetostatics and applications, plane waves, examples and applications to RF, microwave, and optical systems.

135. Optical Fiber Communication

(4) DAGLI

Prerequisites: ECE 132 and 134 with a minimum grade of C- in both. *Lecture, 3 hours; discussion, 1 hour.*

Optical fiber as a transmission medium, dispersion and nonlinear effects in fiber transmission, fiber and semiconductor optical amplifiers and lasers, optical modulators, photo detectors, optical receivers, wavelength division multiplexing components, optical filters, basic transmission system analysis and design.

137A. Circuits and Electronics I

(4) RODWELL

Prerequisites: ECE 2A-B-C, 130A, and 132 with a minimum grade of C- in all; open to EE majors only. *Lecture, 3 hours; laboratory, 3 hours.*

Analysis and design of single stage and multistage transistor circuits including biasing, gain, impedances and maximum signal levels.

137B. Circuits and Electronics II

(4) RODWELL

Prerequisites: ECE 2C and 137A with a minimum grade of C- in both; open to EE majors only. *Lecture, 3 hours; laboratory, 3 hours.*

Analysis and design of single stage and multistage transistor circuits at low and high frequencies. Transient response. Analysis and design of feedback circuits. Stability criteria.

139. Probability and Statistics

(4) ILTIS

Prerequisite: Open to Electrical Engineering, Computer Engineering and pre-Computer Engineering majors only. Lecture, 3 hours; discussion, 2 hours.

Fundamentals of probability, conditional probability, Bayes rule, random variables, functions of random variables, expectation and high-order moments, Markov chains, hypothesis testing.

141A. Introduction To Nanoelectromechanical and Microelectromechanical Systems (NEMS/MEMS)

(3) PENNATUR, TURNER

Prerequisites: ME 16 & 17, ME 152A, ME 151A (may be concurrent); or, ECE 130A and 137A with a minimum grade of C- in both.

Same course as ME 141A. Lecture, 3 hours.

Introduction to nano- and microtechnology. Scaling laws and nanoscale physics are stressed. Individual subjects at the nanoscale including materials, mechanics, photonics, electronics, and fluidics will be described, with an emphasis on differences of behavior at the nanoscale and real-world examples.

141B. MEMS: Processing and Device Characterization

(4) PENNATHUR, TURNER

Prerequisites: ME 141A, ME 163 (may be concurrent); or ECE 141A.

Same course as ME 141B. Lecture, 2 hours; laboratory, 6 hours.

Lectures and laboratory on semiconductor-based processing for MEMS. Description of key equipment and characterization tools used for MEMS and design, fabrication, characterization and testing of MEMS. Emphasis on current MEMS devices including accelerometers, comb drives, micro-reactors and capacitor-actuators.

141C. Introduction to Microfluidics and BioMEMS

(3) MEINHART

Prerequisite: ME 141A or ECE 141A; open to ME and EE majors only.

Same course as ME 141C. Lecture, 3 hours.

Introduces physical phenomena associated with microscale/nanoscale fluid mechanics, microfluids, and bioMEMS. Analytical methods and numerical simulation tools are used for analysis of microfluids.

144. Electromagnetic Fields and Waves

(4) YORK

Prerequisite: ECE 134 with a minimum grade of C-. Lecture, 3 hours; laboratory, 3 hours.

Waves on transmission lines, Maxwell's equations, skin effect, propagation and reflection of electromagnetic waves, microwave integrated circuit principles, metal and dielectric waveguides, resonant cavities, antennas. Microwave and optical device examples and experience with modern microwave and CAD software.

145A. Communication Electronics

(5) RODWELL

Prerequisites: ECE 137A-B with a minimum grade of C- in both. Lecture, 3 hours; laboratory, 6 hours.

RF/Microwave circuits. Transistor, transmission-line, and passive element characteristics. Transmission-line theory and impedance matching. Amplifier design for maximum available gain. Amplifier stability. Gain compression and power limits. Introduction to noise figure, and to intermodulation distortion.

145B. Communication Electronics II

(5) YUE

Prerequisite: ECE 145A with a minimum grade of C-; EE majors only. Lecture, 3 hours; laboratory, 6 hours.

RF models for CMOS and BJT. Discrete vs. IC implementation. On-chip passive components. LNAs. PAs. T/R switches. Mixers. VCOs. Poly-phase filters. Radio link budget. Analog and digital modulation schemes. Introduction to receiver architectures. I&Q modulation. Image-reject architectures.

145C. Communication Electronics III

(5) YUE

Prerequisites: ECE 137B with a minimum grade of C-. Lecture, 4 hours.

Modern wireless communication standards. Cellular phone. Wireless LAN. Introduction to multi-access techniques. Advanced modulation schemes. Interference and distortion. Modern transceiver architectures. Direct conversion vs. low IF vs. superheterodyne. Sub-sampling receiver. Direct polar modulator. Frequency synthesis using PLL.

146A. Analog Communication Theory and Techniques

(5) ILTIS

Prerequisites: ECE 130A-B with a minimum grade of C- in both; open to EE majors only. Lecture, 3 hours; laboratory, 6 hours.

Modulation theory, AM, FM, PM, and analog pulse modulation and demodulation techniques. System noise and performance calculations.

146B. Digital Communication Theory and Techniques

(5) SHYNK

Prerequisites: ECE 130A-B, 140 and 146A with minimum grades of C-; open to EE majors only. Lecture, 3 hours; laboratory, 6 hours.

Elements of source coding: quantization, pulse code modulation, delta modulation. Introduction to digital modulation over baseband and passband channels: linear modulation, Nyquist criterion for intersymbol interference avoidance, orthogonal modulation. Optimal reception of signals in Additive White Gaussian Noise: detection theory basics, signal space concepts, geometry of maximum likelihood receivers. Performance analysis of optimal receivers: error probability as a function of E_b/N_0 , union bound, nearest neighbors approximation. Link design: power-bandwidth tradeoffs, link budget analysis.

147A. Feedback Control Systems - Theory and Design

(5) TEEL, SMITH

Prerequisites: ECE 130A-B-C with a minimum grade of C- in each; open to EE and computer engineering majors only. Lecture, 3 hours; laboratory, 6 hours.

Feedback systems design, specifications in time and frequency domains. Analysis and synthesis of closed loop systems. Computer aided analysis and design.

147B. Digital Control Systems - Theory and Design

(5) SMITH, TEEL

Prerequisite: ECE 147A with a minimum grade of C-; open to EE and computer engineering majors only. Lecture, 3 hours; laboratory, 6 hours.

Analysis of sampled data feedback systems; state space description of linear systems; observability, controllability, pole assignment, state feedback, observers. Design of digital control systems. (W)

147C. Control System Design Project

(5) HESPANHA

Prerequisite: ECE 147A or ME 155B or ME 173 with a minimum grade of C-. Lecture, 3 hours; laboratory, 6 hours.

Students are required to design, implement, and document a significant control systems project. The project is implemented in hardware or in high-fidelity numerical simulators. Lectures and laboratories cover special topics related to the practical implementation of control systems.

148. Applications of Signal Analysis and Processing

(4) LEE

Prerequisites: ECE 130A-B with a minimum grade of C- in both. Lecture, 3 hours; discussion, 2 hours.

A sequence of engineering applications of signal analysis and processing techniques; in communications, image processing, analog and digital filter design, signal detection and parameter estimation, holography and tomography, Fourier optics, and microwave and acoustic sensing.

149. Active and Passive Network Synthesis

(4) ILTIS

Prerequisite: Upper-division standing; open to EE majors only.

Designed for juniors to take right after ECE 130AB.

Combines the areas of electronics and network theory in the subject of passive and active network design. Topics include passive synthesis, optimization techniques, approximations to ideal filters, distributed networks, sensitivity and the modern design techniques, and applications of active filters.

151. Distributed Systems

(4) MELLIAR-SMITH

Prerequisite: Computer Science 170 with a minimum grade of C-.

Not open for credit to students who have completed Computer Science 171. Lecture, 3 hours; discussion, 1 hour.

Distributed systems architecture, distributed programming techniques, message passing, remote procedure calls, group communication and membership, naming, asynchrony, causality, consistency, fault-tolerance and recovery, resource management, scheduling, monitoring, testing and debugging.

152A. Digital Design Principles

(5) RODOPLU

Prerequisites: ECE 15 or 15A or Computer Science 30 with a minimum grade of C- in each course; open to electrical engineering, computer engineering, and computer science majors only. Lecture, 3 hours; laboratory, 6 hours.

Design of synchronous digital systems: timing diagrams, propagation delay, latches and flip-flops, shift registers and counters, Mealy/Moore finite state machines, Verilog, 2-phase clocking, timing analysis, CMOS implementation, S-RAM, RAM-based designs, ASM charts, state minimization.

152B. Digital Design Methodologies

(5) CHENG

Prerequisites: ECE 152A with a minimum grade of C-; open to EE, computer engineering, and computer science majors only. Lecture, 3 hours; discussion, 6 hours.

Design methodologies of digital systems, the register and processor levels. Design of functional subsystems, including arithmetic processors, hardwired and microprogrammed control units, memory systems, and bussing systems. System organization including communication, input/output systems, and multiple CPU systems.

153A. Hardware/Software Interface

(4) BREWER, KRINTZ

Prerequisite: Upper division standing in Computer Engineering, Computer Science or Electrical Engineering.

Same course as Computer Science 153A.

Issues in interfacing computing systems and software to practical I/O interfaces. Rapid response, real-time events and management of tasks, threads, and scheduling required for efficient design of embedded software and systems is discussed. Techniques for highly constrained systems.

153B. Sensor and Peripheral Interface Design

(4) BUTNER

Prerequisites: ECE 152B and 153A with a minimum grade of C- in both. Lecture, 3 hours; laboratory, 3 hours.

Hardware description languages; field-programmable logic and ASIC design techniques. Mixed-signal techniques: A/D and D/A converter interfaces; video and audio signal acquisition, processing and generation, communication and network interfaces.

154. Introduction to Computer Architecture

(4) PARHAMI

Prerequisite: ECE 152A with a minimum grade of C-; open to EE, computer engineering, and computer science majors only.

Not open for credit to students who have completed Computer Science 154. Lecture, 3 hours; discussion, 1 hour.

The computer design space. Methods of performance evaluation. Machine instructions and

assembly language. Variations in instruction set architecture. Design of arithmetic/logic units. Data path and control unit synthesis. Pipelining and multiple instruction issue. Hierarchical memory systems. Input/output and interfacing. High-performance systems, including multiprocessors and multicomputers.

155A. Introduction to Computer Networks

(4) MOSER

Prerequisite: ECE 154 with a minimum grade of C-; and, Computer Science 12 or 60 with a minimum grade of C-.

Not open for credit to students who have completed Computer Science 176 or 176A, or ECE 155. Lecture, 3 hours; discussion, 1 hour.

Topics in this course include network architectures, protocols, wired and wireless networks, transmission media, multiplexing, switching, framing, error detection and correction, flow control, routing, congestion control, TCP/IP, DNS, email, World Wide Web, network security, socket programming in C/C++.

155B. Network Computing

(4) MOSER

Prerequisites: ECE 155A with a minimum grade of C-; and, Computer Science 5JA or 10 or 11JA with a minimum grade of C-.

Not open for credit to students who have completed Computer Science 176B or ECE 194W. Lecture, 3 hours; discussion, 1 hour.

Topics in this course include client/server computing, threads, Java applets, Java sockets, Java RMI, Java servlets, Java Server Pages, Java Database Connectivity, Enterprise Java Beans, Hypertext Markup Language, extensible Markup Language, Web Services, programming networked applications in Java.

156A. Digital Design with VHDL and Synthesis

(4) WANG

Prerequisite: ECE 152A with a minimum grade of C-. Lecture, 3 hours; laboratory, 3 hours.

Introduction to VHDL basic elements. VHDL simulation concepts. VHDL concurrent statements with examples and applications. VHDL subprograms, packages, libraries and design units. Writing VHDL for synthesis. Writing VHDL for finite state machines. Design case study.

156B. Computer-Aided Design of VLSI Circuits

(4) WANG

Prerequisite: ECE 156A with a minimum grade of C-. Lecture, 3 hours; laboratory, 3 hours.

Introduction to computer-aided simulation and synthesis tools for VLSI. VLSI system design flow, role of CAD tools, layout synthesis, circuit simulation, logic simulation, logic synthesis, behavior synthesis and test synthesis.

158. Digital Signal Processing

(4) MITRA

Prerequisites: ECE 130A-B with a minimum grade of C- in both; open to EE majors only.

Lecture, 3 hours; laboratory, 3 hours.

Discrete signals and systems, convolution, z-transforms, discrete Fourier transforms, digital filters.

160. Multimedia Systems

(4) MELLIAR-SMITH

Prerequisites: upper-division standing; open to EE, computer engineering, computer science, and creative studies majors only. Lecture, 3 hours; laboratory, 3 hours.

Introduction to multimedia and applications, including WWW, image/video databases and video streaming. Covers media content analysis, media data organization and indexing (image/video databases), and media data distribution and interaction (video-on-demand and interactive TV).

162A. The Quantum Description of Electronic Materials

(4) BOWERS

Prerequisites: ECE 130A-B and 134 with a minimum grade of C- in all; open to EE and materials majors only.

Same course as Materials 162A. Lecture, 4 hours.

Electrons as particles and waves, Schrodinger's equation and illustrative solutions. Tunneling. Atomic structure, the exclusion principle and the periodic table. Bonds. Free electrons in metals, periodic potentials and energy bands.

162B. Fundamentals of the Solid State

(4) COLDREN

Prerequisite: ECE 162A with a minimum grade of C-; open to EE and materials majors only.

Same course as Materials 162B. Lecture, 3 hours; discussion, 1 hour.

Crystal lattices and the structure of solids, with emphasis on semiconductors. Lattice vibrations, electronic states and energy bands. Electrical and thermal conduction. Dielectric and optical properties. Semiconductor devices: diffusion, p-n junctions and diode behavior.

162C. Optoelectronic Materials and Devices

(4) COLDREN

Prerequisites: ECE 162A-B with a minimum grade of C-; open to electrical engineering and materials majors only. Lecture, 3 hours; discussion, 1 hour.

Optical transitions in solids. Direct and indirect gap semiconductors. Luminescence. Excitons and photons. Fundamentals of optoelectronic devices: semiconductor lasers, Led's photoconductors, solar cells, photo diodes, modulators. Photoemission. Integrated circuits.

178. Introduction to Digital Image and Video Processing

(4) MANJUNATH

Prerequisites: open to EE, computer engineering, and computer science majors with upper-division standing. Lecture, 3 hours; discussion, 1 hour.

Basic concepts in image and video processing. Topics include image formation and sampling, image transforms, image enhancement, and image and video compression including JPEG and MPEG coding standards.

181A. Introduction to Robotics: Robot Mechanics

(4) PADEN

Same course as ME 170A.

Recommended preparation: ME 16. Lecture, 3 hours; laboratory, 3 hours.

Overview of robot kinematics and dynamics. Structure and operation of industrial robots. Robot performance: work space, velocity, precision, payload. Comparative discussion of robot mechanical designs. Actuators. Robot coordinate systems. Kinematics of position. Dynamics of manipulators.

(S; may not be offered every year)

181B. Introduction to Computer Vision

(4) MANJUNATH

Prerequisite: Upper-division standing.

Same course as Computer Science 181B.

Overview of computer vision problems and techniques for analyzing the content of images and video. Topics include image formation, edge detection, image segmentation, pattern recognition, texture analysis, optical flow, stereo vision, shape representation and recovery techniques, issues in object recognition, and case studies of practical vision systems.

181C. Introduction to Robotics: Robot Control

(4) PADEN

Prerequisite: ECE 2A-B-C with a minimum grade of C-; or ME 104.

Same course as ME 170C. Lecture, 2 hours; laboratory, 4 hours.

Overview of robot control technology from open-loop manipulators and sensing systems, to single-joint servovalves and servomotors, to integrated adaptive force and position control using feedback from machine vision and touch sensing systems. Design emphasis on accurate tracking accomplished with minimal algorithm complexity. (F; may not be offered every year)

183. Nonlinear Phenomena

(4) TEEL

Prerequisites: Physics 105A or ME 163 or upper-division standing in EE.

Same course as Physics 106 and ME 169. Not open for credit to students who have completed ECE 163C. Lecture, 3 hours; discussion, 1 hour.

An introduction to nonlinear phenomena. Flows and bifurcations in one and two dimensions, chaos, fractals, strange attractors. Applications to physics, engineering, chemistry, and biology.

188A. Senior Electrical Engineering Project

(4) STAFF

Prerequisites: Consent of instructor; completion of at least four required upper division Electrical Engineering courses with a 3.0 GPA or higher.

Student groups design a significant project based on the knowledge and skills acquired in earlier coursework and integrate their technical knowledge through a practical design experience. The project is evaluated through written reports, oral presentations, and demonstrations of performance.

188B. Senior Electrical Engineering Project

(4) STAFF

Prerequisites: ECE 188A with a minimum grade of C-.

Student groups design a significant project based on the knowledge and skills acquired in earlier coursework and integrate their technical knowledge through a practical design experience. The project is evaluated through written reports, oral presentations, and demonstrations of performance.

189A. Senior Computer Systems Project

(4) BUTNER

Prerequisite: ECE 152B; senior standing in Computer Engineering, Computer Science or EE. *Not open for credit to students who have completed Computer Science 189A-B.*

Student groups design a significant computer-based project. Groups work independently with interaction among groups via interface specifications and informal meetings.

189B. Senior Computer Systems Project

(4) BUTNER

Prerequisite: ECE 189A; senior standing in Computer Engineering, Computer Science or ECE. *Not open for credit to students who have completed Computer Science 189A-B.*

Student groups design a significant computer-based project. Groups work independently with interaction among groups via interface specifications and informal meetings.

192. Projects in Electrical and Computer Engineering

(4) STAFF

Prerequisite: consent of instructor. Discussion, 2 hours; laboratory, 6 hours.

Projects in electrical and computer engineering for advanced undergraduate students.

193. Internship in Industry

(1-8) STAFF

Prerequisite: consent of department.

Must have a 3.0 grade-point-average. May not be used as departmental electives. May be repeated to a maximum of 12 units. Field, 1-8 hours.

Special projects for selected students. Offered in conjunction with engineering practice in selected industrial and research firms, under direct faculty supervision.

194AA-ZZ. Special Topics in Electrical and Computer Engineering

(1-5) STAFF

Prerequisite: consent of instructor. Variable hours.

Group studies intended for small number of advanced students who share an interest in a topic not included in the regular departmental curriculum. Topics covered include (check with department for quarters offered): A. Circuits; AA. Micro-Electro-Mechanical Systems; B. Systems Theory; BB. Computer Engineering; C. Communication Systems; D. Control Systems; E. Signal Processing; F. Solid State; G. Fields and Waves; H. Quantum Electronics; I. Microwave Electronics; J. Switching Theory; K. Digital Systems Design; L. Computer Architecture; M. Computer Graphics;

N. Pattern Recognition; O. Microprocessors and Microprocessor-based Systems; P. Simulation; Q. Imaging Systems and Image Processing; R. General; S. Speech; T. Robot Control; U. Optoelectronics; V. Scientific Computation; W. Computer Network; X. Distributed Computation; Y. Numerical Differential Equations; Z. Nanotechnology

196. Undergraduate Research

(2-4) STAFF

Prerequisites: upper-division standing; consent of instructor.

Must have a minimum 3.0 grade-point average for the preceding three quarters. May be repeated for up to 12 units. Not more than 4 units may be applied to departmental electives.

Research opportunities for undergraduate students. Students will be expected to give regular oral presentations, actively participate in a weekly seminar, and prepare at least one written report on their research.

199. Independent Studies in Electrical and Computer Engineering

(1-5) STAFF

Prerequisites: upper division standing; completion of two upper-division courses in electrical and computer engineering; consent of instructor.

Must have a minimum 3.0 grade-point average for the preceding three quarters. Students are limited to five units per quarter and 30 units total in all 98/99/198/199/199DC/199RA courses combined.

Directed individual study, normally experimental.

GRADUATE COURSES

Graduate courses for this major can be found in the *UCSB General Catalog*.

Engineering Sciences

Engineering Sciences, Office of Associate Dean for Undergraduate Studies, Harold Frank Hall, Room 1006;

Telephone (805) 893-2809

Web site: <http://engrsci.ucsb.edu>

Chair & Associate Dean: Glenn E. Beltz
Director of Technology Management Program: Robert A. York

Faculty

Glenn E. Beltz, Ph.D., Harvard, Professor

John E. Bowers*, Ph.D., Stanford University, Professor

Gary S. Hansen*, Ph.D., University of Michigan, Associate Professor

Jeffrey M. Moehlis, Ph.D., University of California, Berkeley, Associate Professor

Linda R. Petzold, Ph.D., University of Illinois at Urbana-Champaign, Professor

David Seibold*, Ph.D., Michigan State University, Professor

Robert A. York*, Ph.D., Cornell University, Professor

* Technology Management Program faculty

The Engineering Sciences program at UCSB serves as a focal point for the cross-disciplinary educational environment that prevails in each of our five degree-granting undergraduate programs (chemical engineering, computer engineering, computer science, electrical engineering, and mechanical engineering). The courses offered in this "department" are designed to cultivate well-educated, innovative engineers and scientists with excellent management and entrepreneurial skills and attitudes oriented to new technologies.

One of the missions of the Engineering Sciences program is to provide coursework commonly needed across other educational programs in the College of Engineering. For example, courses in computer programming, computation, ethics, engineering writing, engineering economics, science communication to the public, and even an aeronautics-inspired art course are offered.

Engineering Sciences Courses

LOWER DIVISION

3. Introduction to Programming for Engineers

(3) STAFF

Prerequisites: Open to chemical engineering, electrical engineering, and mechanical engineering majors only.

General philosophy of programming for engineering majors. Students will be introduced to a modern programming language or software package. Specific areas of study will include algorithms, basic decision structures, arrays, matrices, and graphing. Engineering applications will be emphasized. (F, S, M).

99. Introduction to Research

(1-3) STAFF

Prerequisite: Consent of instructor.

May be repeated for credit to a maximum of 6 units. Students are limited to 5 units per quarter and 30 units total in all 98/99/198/199/199AA-ZZ courses combined. Directed study to be arranged with individual faculty members. Course offers exceptional students an opportunity to participate in a research group.

UPPER DIVISION

101. Ethics in Engineering

(3) STAFF

Prerequisite: senior standing in engineering.

The nature of moral value, normative judgment, and moral reasoning. Theories of moral value. The engineer's role in society. Ethics in professional practice. Safety, risk, responsibility. Morality and career choice. Code of ethics. Case studies will facilitate the comprehension of the concepts introduced. (W,S)

102AA-ZZ. Special Topics in Engineering, Business, and Society

(1) STAFF

Prerequisites: Upper-division standing.

May be repeated for credit if there is no duplication of course content.

A series of weekly lectures given by university staff and outside experts in all fields of new technology management.

103. Advanced Engineering Writing

(4) STAFF

Prerequisites: Writing 50 or 50E; upper-division standing.

Practice in the forms of communication—contractual reports, proposals, conference papers, oral presentations, business plans—that engineers and entrepreneurial engineers will encounter in professional careers. Focus is on research methods, developing a clear and persuasive writing style, and electronic document preparation.

111. Opportunities and Perspectives in Technology, Business, and Society

(1) STAFF

Prerequisite: Writing 2 with a minimum grade of B; and Writing 50 or equivalent with a minimum grade of B.

Writing 50 or equivalent in the prerequisites is intended to include: ENGL 10, WRIT 50, WRIT 105, WRIT 107 & WRIT 109

This course replaces the ENGR 102A-B-C series.

A series of lectures by faculty and visiting speakers covering new advances, business practices, and opportunities in technology, innovation management, entrepreneurship, education, and social responsibility.

120. Business Strategy & Leadership Skills

(4) HANSEN

Prerequisite: Writing 2 with a minimum grade of B-; and, Writing 50 or equivalent with a minimum grade of B-; and upper division standing.

An introduction to key business principles and practices including selected management theories, models and tools in strategy, finance, marketing and sales. Also explores the role and impact of leadership in achieving business value through organizational effectiveness. Class uses case studies, lectures, and computer simulation.

126. New Venture Finance

(2) STAFF

Prerequisite: Economics 1 or Economics 3A with a minimum grade of B-.

Presents the tools necessary for the strategic analysis and understanding of financial information particular to new ventures. Provides insight into how financial information can be used to design optimal financing strategies, prepare valuation models for new ventures, and assist in strategic planning for the venture.

130. Project Management and Managing Operations

(2) STAFF

