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.

**Bachelor of Science—Electrical Engineering**

A minimum of 189 units is required for graduation. A complete list of requirements for the major can be found on page 52. 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. The 32 units of departmental electives must include at least 2 sequences, one of which must be an approved EE Senior Capstone Design/Project course sequence. 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 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, Mathematics 4A-B and Mathematics 6A and 6B 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 25.

**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**

1A. Computer Engineering Seminar (1) STAFF
   Prerequisite: Open to computer engineering majors only. Seminar: 1 hour
   Introductory seminar to expose students to a broad range of topics in Computer Engineering.

1B. Ten Puzzling Problems in Computer Engineering (1) STAFF
   Prerequisite: Open to pre-computer engineering and computer engineering majors only. Not open for credit for those who have taken ECE 1
   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.

3. Introduction to Electrical Engineering (4) STAFF
   Prerequisite: Open to EE majors only. Lecture, 3 hours; laboratory, 2 hours
   Introduction to fundamental design problems in Electrical Engineering through programming. Includes basic concepts of software engineering, algorithm design, data structures, with design problems derived from signals systems. Specific areas will include I-D and 2-D signal processing, basic transforms and applications.

5. Introduction to Electrical & Computer Engineering (4) STAFF
   Prerequisite: Open only to Electrical and Computer Engineering majors. Lecture: 2 hours; Laboratory: 3 hours
   Aims at exposing freshmen students to the different sub-fields within Electrical and Computer Engineering. Composed of lectures by different faculty members and a weekly laboratory based on projects that are executed using the Arduino environment.

10A. Foundations of Analog and Digital Circuits & Systems (3) STAFF
   Prerequisite: Mathematics 2A-B or 3A-B or Mathematics 3AH-3BH, and Mathematics 3C or 4A or 4B with a minimum grade of C and Math 4B or 4BI or 5A with a minimum grade of C (may be taken concurrently); Physics 3 or 23 (may be taken concurrently); open only to electrical and computer engineering majors. Lecture: 3 hours
   Not open for credit for those who have received a C- or higher in ECE 2A.

The objective of the course is to establish the foundations of analog and digital circuits. The course will introduce the student to the power of abstraction,
resistive networks, network analysis, nonlinear analysis and the digital abstraction. (F)

10AL. Foundations of Analog and Digital Circuits and Systems Lab
(2) STAFF
Prerequisite: ECE 10A (may be taken concurrently) with a C- or better grade.
Laboratory: 4 hours
Not open for credit for those who have received a C- or higher in ECE 2A.

The goal of 10AL is to provide the student with a hands-on application of the concepts discussed in ECE 10A. The lab will introduce the use of microcontrollers as a data acquisition system, network analysis, resistors, nonlinear analysis and digital abstraction.

10B. Foundations of Analog and Digital Circuits and Systems
(3) STAFF
Prerequisite: ECE 10A with a C- or better grade.
Lecture: 3 hours
Not open for credit for those who have received a C- or higher in ECE 2B.

The objective of the course is to introduce the MOSFET both as a simple digital switch and as a controlled current source for analog design. The course will cover basic digital design, small-signal analysis, charge storage elements and operational amplifiers. (W)

10BL. Foundations of Analog and Digital Circuits and Systems Lab
(2) STAFF
Prerequisite: ECE 10B (may be taken concurrently) with a C- or better grade. Laboratory: 4 hours
Not open for credit for those who have received a C- or higher in ECE 2B.

The goal of 10BL is to provide the student with a hands-on application of the concepts discussed in ECE 10B. The lab will utilize the microcontroller to introduce students to the understanding of datasheets for both digital and analog circuits, single-stage amplifier design and basic instrumentation.

10C. Foundations of Analog and Digital Circuits and Systems
(3) STAFF
Prerequisite: ECE 10B with a C- or better grade.
Lecture: 3 hours
Not open for credit for those who have received a C- or higher in ECE 2C.

The objective of the course is to introduce the student to the basics of semiconductor devices. The course will cover energy and power dissipation in digital circuits, first-order and second-order time invariant circuits, sinusoidal steady state, impedance representation, feedback and resonance. (S)

10CL. Foundations of Analog and Digital Circuits and Systems Lab
(2) STAFF
Prerequisite: ECE 10C (may be taken concurrently) with a C- or better grade. Laboratory: 4 hours
Not open for credit for those who have received a C- or higher in ECE 2C.

The goal of 10CL is to provide the student with a hands-on application of the concepts discussed in ECE 10C. The lab will utilize the microcontroller to introduce students to the understanding of propagation delay in digital circuits and the resulting power dissipation, first order linear networks, second order linear networks, sinusoidal steady-state, impedance analysis and op-amp circuits.

15A. Fundamentals of Logic Design
(4) ZHANG
Prerequisites: 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, mull-level circuits, combinational circuit design and simulation, multiplexers, decoders, programmable logic devices.

92. Projects in Electrical and Computer Engineering
(4) STAFF
Prerequisite: Consent of instructor; for Electrical Engineering and Computer Engineering majors only.
Projects in electrical and computer engineering for advanced undergraduate students.

94AA-ZZ. Group Studies in Electrical and Computer Engineering
(1-4) STAFF
Prerequisite: consent of instructor.
Group studies for a small number of advanced students who share an interest in a topic not included in the regular departmental curriculum.

96. Undergraduate Research
(2-4) STAFF
Prerequisite: Consent of instructor. Must have a 3.00 GPA. May be repeated for up to 12 units.
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.

UPPER DIVISION

120A. Integrated Circuit Design and Fabrication
(4) BEN-YAACOV
Prerequisite: ECE 132 with a minimum grade of C-.
Lecture: 3 hours; Laboratory: 3 hours
Not open for credit for those who have taken ECE 124B.

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.

120B. Integrated Circuit Design and Fabrication
(4) BEN-YAACOV
Prerequisite: Either ECE 120A or ECE 124B with a minimum grade of C- or better in each of the courses.
Lecture: 3 hours; Laboratory: 3 hours
Not open for credit for those who have taken ECE 124C.

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.

122A. VLSI Principles
(4) BANERJEE
Prerequisite: ECE 152A with a minimum grade of C- in each; open to EE and computer engineering majors only.
Lecture: 3 hours; Discussion: 2 hours

122B. VLSI Architecture and Design
(4) BREWER
Prerequisite: ECE 124A or ECE 123 or ECE 122A with a minimum grade of C-.
Lecture: 3 hours; Laboratory: 2 hours
Not open for credit for those who have taken ECE 124A or ECE 123.

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.

122C. VLSI Fabrication
(4) BANERJEE
Prerequisite: ECE 152A with a minimum grade of C-.
Lecture: 3 hours; Discussion: 2 hours
Electronics 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.

132. Introduction to Solid-State Electronic Devices
(4) STAFF
Prerequisite: Physics 4 or 24 with a minimum grade of C-; Mathematics 4B or 5A with a minimum grade of C-; and, ECE 10A-B and ECE 10BL-CL or 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.
Not open for credit for those who have taken ECE 124A or ECE 122A.
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.

125. High-Speed Digital Integrated Circuit Design
(4) BANERJEE
Prerequisite: ECE 124A or 137A with a minimum grade of C- in each; 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. (4)

130A. Signal Analysis and Processing
(4) STAFF
Prerequisite: Mathematics 4B or 5A with a minimum of grade of C and ECE 2B or ECE 10B with a minimum grade of C- in each course; open to EE and computer engineering majors only.
Lecture: 3 hours; Discussion: 2 hours

130B. Signal Analysis and Processing
(4) CHANDRASEKARAN
Prerequisite: ECE 130A with a grade of C- or better; 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: Fourier 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.

134. Introduction to Fields and Waves
(4) DAGLI, YORK
Prerequisite: Physics 3 or 23 with a minimum grade of C-; Mathematics 4B or 4BI or 9A and Mathematics 5B or 6A or 6AI with a minimum grade of C in each; and Mathematics 5C or 6B 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. Waveguide 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) ROODWELL
Prerequisites: ECE 10A-B-C and ECE 10AL-BL-CL or ECE 2A-2B-C, 130A, and 132 at 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) ROODWELL
Prerequisites: ECE 10C and 10CL or 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) STAFF
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 higher order moments, Markov chains, hypothesis testing.

141A. Introduction To Nano-electro-mechanical and Microelectromechanical Systems (NEMS/MEMS)
(3) PENNATUR
Prerequisites: ME 16 A & 17, ME 152A, ME 151A (may be concurrent); or, ECE 130A and 137A with a minimum grade of C- in both.
Introduction to nano- and microtechnology. Scaling laws and nanoscale physics are stressed. Individual subjects at the nanoscale including materials, mechanics, photonics, electronics, and fluids will be described, with an emphasis on differences of behavior at the nanoscale and real-world examples.

141B. MEMS: Processing and Device Characterization
(4) PENNATUR
Prerequisites: ME 141A, ME 163 (may be concurrent); or ECE 141A.
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-resistors and capacitor-actuators. (W)

141C. Introduction to Microfluidics and BioMEMS
(3) MEINHART
Prerequisites: ME 141A or ECE 141A; open to ME and EE majors only.
Introduces physical phenomena associated with microscale/nanoscale fluid mechanics, microfluidics, and bioMEMS. Analytical methods and numerical simulation tools are used for analysis of microfluids.

142. Introduction to Power Electronics
(4) MISRAH
Prerequisite: ECE 132, ECE 134, and ECE 137A with a minimum grade of C- in all; open to EE majors only. Lecture, 3 hours; laboratory, 2 hours.
An introduction to modern switched-mode power electronics and associated devices. Covers modern converter/inverter topologies for the control and conversion of electrical power with high efficiency with applications in power supplies, renewable energy systems, lighting, electric/hybrid vehicles, and motor drivers.

144. Electromagnetic Fields and Waves
(4) KLASKIN
Prerequisite: ECE 134 with a minimum grade of C-. Lecture, 3 hours.
Waves on transmission lines, Maxwell’s equations, skin effect, propagation and reflection of electromagnetic waves, microwave integrated circuit principles, metal-dielectric waveguides, resonant cavities, antennas. Microwave and optical device examples and experience with modern microwave and CAD software.

145A. Communication Electronics I
(4) ROODWELL
Prerequisites: ECE 137A-B with a minimum grade of C- in both. Lecture, 3 hours; laboratory, 6 hours.

145B. Communication Electronics II
(5) BUCKWALTER
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, RF transmitter circuits. Mixers, VCOs. Polyphase filters Radio link budget. Analog and digital modulation schemes. Introduction to receiver architectures. I/Q modulation. Image-reject architectures.

145C. Communication Electronics III
(5) BUCKWALTER
Prerequisite: ECE 145B with a minimum grade of C-. Lecture, 4 hours.

146A. Digital Communication Fundamentals
(5) MADHOW
Prerequisite: ECE 130A-B with a minimum grade of C-; open to EE majors only. Lecture: 3 hours; Laboratory: 6 hours
Signal and channel models, with emphasis on wireless systems; digital modulation; demodulation basics; channel capacity; review of probability theory and random variables.

146B. Communication Systems Design
(5) MADHOW
Prerequisite: ECE 130A-B and 146A with minimum grades of C-; open to EE majors only. Lecture: 3 hours; Laboratory: 6 hours
Optimal modulation, including signal space geometry; communication performance characterization; advanced wireless communication techniques, including multi-antenna and multicarrier systems; other emerging frontiers in communications.

147A. Feedback Control Systems - Theory and Design
(5) TEEL
Prerequisites: ECE 130A-B with a minimum grade of C- in each; open to ECE 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) BYL
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 descriptions; observability, controllability, pole assignment, state feedback, observers. Design of digital control systems. (W)

147C. Control System Design Project
(4) STAFF
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
Prerequisite: ECE 130A and 130B 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. Game Theory for Networked Systems
(4) MARDEN
Prerequisite: UPPER DIVISION STANDING OR CONSENT OF INSTRUCTOR.
An overview of game theory with an emphasis on application to multiagent systems. Game theory focuses on the study of systems that are comprised of interacting and possibly competing decision-making entities. Examples drawn from engineered, economics, and social systems.

150. Mobile Embedded Systems
(4) STAFF
Prerequisite: Proficiency in JAVA programming, and a C- in ECE 152A.
Architectures of modern smartphones and their key hardware components including mobile application processors, communications chips, display, touchscreen, graphics, camera, battery, GPS, and various sensors; the OS and software development platform of smartphones; smartphone applications; low power design techniques.

152A. Digital Design Principles
(5) STAFF
Prerequisite: ECE 151A and 1A-B or ECE 10A & ECE 10AL with a minimum grade of C- in each course; or Computer Science 30 or 64 with a minimum grade of C- in each course; or 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, minimalization.

153A. Hardware/Software Interface
(4) KRINTZ
Prerequisite: Upper division standing in Computer Engineering, Computer Science or Electrical Engineering.
Same course as Computer Science 153A. Issues in interfacing computer systems and software to practical I/O interfaces. Rapid response, real-time events and time-related tasks, 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) STAFF
Prerequisite: ECE 152A with a minimum grade of C-.
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.

154A. Introduction to Computer Architecture
(4) PARMHEND
Prerequisite: ECE 152A with a minimum grade of C-; open to EE and CMPEN majors only. Lecture: 3 hours; Discussion: 1 hour.
Not open for credit to students who have completed Computer Science 154. ECE 154A is the formerly numbered ECE 154. Students who have taken ECE 154 and have received a grade of C- or lower may take ECE 154A for a better grade.

Instruction-set architecture (ISA) and computer performance; Machine instructions, assembly, addressing modes, maps, pointers; Procedure calls; Number formats; Simple ALUs; Data path, control, microprogram; Buses, I/O programming, interrupts; Pipelined data paths and control schemes.

154B. Advanced Computer Architecture
(4) STRUKOV
Prerequisite: ECE 154A with a C- grade or better. Open to EE and CMPEN majors only. Lecture: 3 hours; Laboratory: 3 hours.
Not open for credit to those who have taken Computer Science 154.

ISA variations; Pipeline data and control hazards; Fast ALU design; multithreading, VLIW; Vector and array processing, multi/many-core chips; Cache and virtual memory; Disk arrays; Shared- and distributed-memory systems, supercomputers; Reconfigurable and application-specific circuits.

157A. Machine Learning in Design and Test Automation
(4) L.C. WANG
Prerequisite: ECE 152A with a minimum grade of C-.
Introduces the various machine learning techniques and how they are utilized to improve hardware design and test automation processes. The various benefits and theoretical barriers for implementing a machine learning solution in practice are explained.

157B. Artificial Intelligence in Design and Test Automation
(4) L.C. WANG
Prerequisite: ECE 157A with a minimum grade of C-.
Introduces an artificial intelligence system view to apply machine learning in design and test automation process. The various components for building an Intelligent Engineering Assistant (IEA) to perform an engineering task in an industrial setting are explained.

158. Digital Signal Processing
(4) GIBSON
Prerequisites: ECE 130A-B with a minimum grade of C- in both; open to EE majors only.
Lecture: 3 hours; laboratory: 3 hours.
Recommended Preparation: Mathematics 124A. Mathematics 124A is recommended but not required.

Digital Signal Processing, with Applications: The Fast Fourier transform, discrete cosine transform, and multi/multirate digital signal processing techniques, with applications to digital cellular communications and wireless access points, and audio, voice, still image, video, and biological signal analysis, recognition and compression.

160. Multimedia Systems
(4) MANJUNATH
Prerequisite: Upper-division standing; open to electrical engineering, computer engineering, computer science, and creative studies majors only.
Lecture: 3 hours; Laboratory: 3 hours.
Not open for credit to students who have completed CMPSC 182.

Introduction to multimedia and applications, including WWW, image/video databases and video streaming. Covers media content analysis, multimedia 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) STAFF
Prerequisites: ECE 130A-B and 134 with a minimum grade of C- in all; open to EE, seniors in the BS/MS program and Materials graduate students only.

Same course as Materials 162A. Lecture, 4 hours.
Electrons as particles and waves, Schrödinger’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) STAFF
Prerequisite: ECE 162A with a minimum grade of C-; open to EE, senior students in the BS/MS programs and Materials graduate students only.

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

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

178. Introduction to Digital Image and Video Processing
(4) STAFF
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. Techniques include image formation and sampling, image transforms, image enhancement, and image and video compression including JPEG and MPEG coding standards.

179D. Introduction to Robotics: Dynamics and Control
(4) BYL
Prerequisites: ECE 130A or ME 155A (may be taken concurrently).

Same course as ME 179D.
Dynamic modeling and control methods for robotic systems. LaGrangian method for deriving equations of motion, introduction to the Jacobian, and modeling and control of forces and contact dynamics at a robotic end effector. Laboratories encourage a problem-solving approach to control.

179P. Introduction to Robotics: Planning and Kinematics
(4) BULLO
Prerequisites: ENGR 5; and either ME 17 or ECE 130C (may be taken concurrently).

Same course as ME 179P.
Motion planning and kinematics topics with an emphasis on geometric reasoning, programming, and matrix computations. Motion planning: configuration spaces, sensor-based planning, decomposition and sampling methods, and advanced planning algorithms. Kinematics: reference frames, rotations and displacements, kinematic motion models.

181. Introduction to Computer Vision
(4) MANJUNATH
Prerequisite: Upper-division standing in Electrical Engineering, Computer Engineering, Computer Science, Chemical Engineering or Mechanical Engineering. Lecture: 3 hours; Discussion: 1 hour.
Same course as Computer Science 181B. Repeatable for credit to students who have completed ECE/CMPSC 181B with a grade of C or better. ECE/CMPSC 181 is a legal repeat of ECE/CMPSC 181B.
project is evaluated through successful completion of milestones and individual/group project reports and presentations.

189B. Senior Computer Systems Project
(4) ISUKAPALLI
Prerequisite: ECE 189A; senior standing in Computer Engineering, Computer Science or EE. Lecture: 3 hours; Laboratory: 3 hours.
Not open for credit to students who have completed Computer Science 189A-B.
Student groups design a significant computer-based project. Focus will be on building and implementing an embedded hardware system. Each group works independently. The project is evaluated through project reports, achieving milestones and through successful demonstration of hardware functionality.

189C. Senior Computer Systems Project
(4) ISUKAPALLI
Prerequisite: ECE 189B; senior standing in Computer Engineering, Computer Science or EE. Lecture: 3 hours; Laboratory: 3 hours.
Not open for credit to students who have completed Computer Science 189A-B.
Student groups design a significant computer-based project. The focus in this course will be on the integration of both hardware and software components. Students continue to work in groups. Apart from project reports and presentations, the evaluation will be based on successful demonstration of both hardware and software aspects of the project.

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
(1-4) 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.

196. Undergraduate Research
(2-4) STAFF
Prerequisite: 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: www.engineering.ucsb.edu/undergraduate/majors-programs/engineering-sciences
Chair & Associate Dean: Glenn E. Beltz
Faculty
Glenn E. Beltz, Ph.D., Harvard, Professor
Jeffrey M. Moehlis, Ph.D., University of California, Berkeley, Professor
Linda R. Petzold, Ph.D., University of Illinois at Urbana-Champaign, Professor
Tyler G. Susko, Lecturer Potential SOE
Robert York, Ph.D., Cornell University, Professor

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) MOEHLIS, PETZOLD
Prerequisites: Open to chemical engineering, electrical engineering, and mechanical engineering majors only.
General philosophy of programming and problem solving. Students will be introduced to the programming language MATLAB. Specific areas of study will include algorithms, basic decision structures, arrays, matrices, and graphing. (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.

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.

160. Science for the Public
(1-4) STAFF
Prerequisite: consent of instructor.
Same course as Physics 160K. Open to graduate students in science and engineering disciplines and to undergraduate science and engineering majors.
Provides experiences in communication, science and technology to nonspecialists. The major components of the course are field work in mentoring, a biweekly seminar, presentations to precollage students and to adult nonscientists, and end-of-term research papers.