

ELECTRICAL ENGINEERING

<https://ee.calpoly.edu/>

The Electrical Engineering Department offers a Bachelor of Science degree and a Master of Science degree in Electrical Engineering. The undergraduate degree is accredited by the Engineering Accreditation Commission of ABET (<http://www.abet.org>).

The mission of the Electrical Engineering Department is to educate students to achieve excellence in the discipline of electrical engineering and to teach them to apply their education to solve practical problems in a socially responsible way. Students are prepared for careers of service, leadership, and distinction in a wide range of engineering and other related fields using a participatory, learn-by-doing, and “hands-on” laboratory, project, and design centered approach. Students are encouraged to participate in lifelong learning as essential in the presence of the ever-increasing pace of technological change.

Diversity in the students, faculty and staff is embraced and enhances the quality and creativity of the campus experience and environment.

The primary educational objectives of the Electrical Engineering program are to prepare graduates to:

1. Excel in the electrical engineering profession, demonstrating technical agility, personal integrity, a collaborative spirit, articulate communication skills, and a global perspective in the design and commercialization of new products and the solution of engineering problems.
2. Achieve personal career satisfaction while making a positive contribution to their employer and to society.
3. Demonstrate understanding of the broad social, economic, and ethical implications of their work.
4. Embrace lifelong learning as necessary to remain current and to further develop in their profession; being prepared to pursue graduate degrees for enhanced skills and opportunities.

The Electrical Engineering degree programs prepare graduates for distinguished practice in professional engineering; equipping students for pursuing engineering solutions to urgent problems while being responsibly aware of all implications. To that end, the curriculum provides a sound theoretical background along with current, practical engineering knowledge. Cal Poly's “learn by doing” philosophy is emphasized by integrating design throughout the curriculum in numerous design-centered laboratories that provide students with hands-on experiences in design synthesis, analysis, characterization, and verification.

The student begins the major in the first quarter with an orientation class and laboratory; and generally, has one or more major courses each quarter until graduation. The many laboratory courses provide practical experience and lead logically from demonstration of theory into design applications.

During their junior and senior years, students choose technical electives to gain additional expertise in one or more areas of specialization within electrical engineering. These courses deal with the development, design and application of circuits, electronic devices, computers, and systems for communication, controls, information processing and display, and system instrumentation. Senior courses in this area provide specialized preparation in a selected area such as active and passive network synthesis, advanced communications systems, software and hardware aspects of computer system design, microelectronic circuit engineering, microprocessor systems applications, rf and microwave engineering, photonics, biomedical engineering, integrated circuits, and solid-state devices.

Other courses deal with industrial process control systems, power electronics, and with generation, distribution, control and utilization of electric power. Senior elective courses in this area provide specialized preparation in a selected area such as advanced control systems, energy conversion, power system analysis, protection and stability, and solid-state motor control.

Employers recognize that students who have completed such specialized technical courses are early contributors in the workforce. Students wishing to pursue graduate work may select appropriate senior courses in keeping with this goal.

In the required senior design project, students demonstrate their understanding of engineering knowledge and their ability to apply that knowledge creatively to solve practical problems.

Involvement in faculty research is possible for graduate students and outstanding undergraduate students. Research areas include computer-aided education, autonomous systems, signal and image processing, electric vehicles, computer architecture and software systems, photonics, polymer electronics, power systems, power electronics, radio frequency electronics, communication systems, biomedical electronics, renewable energy systems, and electric power microgrid systems.

Students are encouraged to participate in professional organizations and clubs such as: Institute of Electrical and Electronics Engineers (IEEE), IEEE Computer Society (IEEE-CS), IEEE Consumer Electronics Society (IEEE-CES), IEEE Power and Energy Society (IEEE-PES), Audio Engineering Society (AES), Cal Poly Robotics, Electric Vehicle Club, Renewable Energy Club, Society of Automotive Engineers (SAE) and the Formula Electric challenge, Society of Women Engineers (SWE), Women Involved in Software & Hardware (WISH), Eta Kappa Nu (HKN), Society of Photo-Optical Instrumentation Engineers (SPIE), Student Electrical Engineering Council (SEEC), and the Amateur Radio Club. The Electric Power Institute, sponsored by the university and underwritten by major utility companies and electrical equipment manufacturers, offers advanced seminars and lectures in the electrical power field and facilitates student and faculty interaction with industry.

Undergraduate Programs

- Electrical Engineering (BS) (<https://catalog.calpoly.edu/engineering/electrical/electrical-engineering-bs/>)

Graduate Programs

- Electrical Engineering (MS) (<https://catalog.calpoly.edu/engineering/electrical/electrical-engineering-ms/>)

EE Courses

EE 1111 Introduction to Electrical Engineering (1 unit)

Term Typically Offered: F

Concurrent: EE 1111L.

A general overview of the field of electrical engineering. Preparation for successful completion of the Electrical Engineering (EE) program at Cal Poly. Success skills and curricular information. Career paths and opportunities. Professional aspects of engineering and electrical engineering. Not open to students with credit in EE 211, EE 241, EE 2211, or EE 2241. 1 lecture. Formerly EE 111.

EE 1111L Introduction to Electrical Engineering Laboratory (1 unit)

Term Typically Offered: F

Concurrent: EE 1111.

A variety of hands-on experiments, skill building exercises and demonstrations in electrical engineering, providing background and motivation for successful completion of the Electrical Engineering (EE) program at Cal Poly. Not open to students with credit in EE 241 or EE 2241. 1 laboratory. Formerly EE 151.

EE 2115L Circuits & Electronics Laboratory for Non-Majors (1 unit)

Term Typically Offered: F, SP

Concurrent: EE 2115.

Construction and characterization of linear and non-linear circuits containing resistors, capacitors, inductors, diodes, op-amps, and voltage comparators. Use of laboratory equipment and circuit simulation software. Principles of circuit analysis for DC, transient, and sinusoidal steady-state (AC) conditions. 1 laboratory.

EE 2115 Circuits & Electronics for Non-Majors (3 units)

Term Typically Offered: F, SP

Prerequisite: MATH 143 or MATH 1262. Concurrent: EE 2115L. Corequisite: PHYS 143 or PHYS 1143.

Analysis and design of circuits comprising resistors, capacitors, inductors, diodes, op-amps, and voltage comparators. Application of KVL, KCL, circuit equivalence, and superposition. Introduction to Laplace transform and network functions. Response of 1st order and 2nd order circuits. Sinusoidal steady-state responses. 3 lectures.

EE 2200 Special Problems for Undergraduates (1-2 units)

Term Typically Offered: F, SP, SU

Prerequisite: Consent of instructor.

Individual investigation, research, studies or surveys of special problems. Repeatable up to 4 units. Formerly EE 200.

EE 2201 Electric Circuits for Non-Majors (2 units)

Term Typically Offered: F, SP

Prerequisite: MATH 143 or MATH 1262. Corequisite: EE 241 or EE 2241; and PHYS 143 or PHYS 1143.

Application of fundamental circuit laws and theorems to the analysis of DC, and steady-state single-phase and three-phase circuits. Not open to Electrical Engineering majors. 2 lectures. Formerly EE 201.

EE 2211 Electric Circuit Analysis I (3 units)

Term Typically Offered: F, SP

Prerequisite: PHYS 143 or PHYS 1143; and MATH 143 or MATH 1262. Corequisite: EE 241 or EE 2241.

Introduction to circuit analysis. Resistive circuits, voltage and current sources, network theorems. Energy storage elements and the transient response of RC, RL, and RLC circuits. AC steady state analysis. 3 lectures. Formerly EE 211.

EE 2212 Electric Circuit Analysis II (3 units)

Term Typically Offered: F, SP

Prerequisite: EE 211 or EE 2211; and one of the following: MATH 242, MATH 244, MATH 2341, or MATH 2343.

AC power analysis in the time domain and phasor domain, Three-phase circuits, Self and mutual inductance, Series and parallel resonance, Two-port networks, and Frequency response including Bode plots. Course may be offered in classroom-based or online format. 3 lectures. Formerly EE 212.

EE 2241 Electric Circuit Analysis Laboratory I (1 unit)

Term Typically Offered: F, SP

Prerequisite: MATH 143 or MATH 1262; and PHYS 143 or PHYS 1143. Corequisite: One of the following: EE 201, EE 2201, EE 211, or EE 2211.

Recommended: EE 151 or EE 1111L.

Use of electrical and electronic test equipment. Experimental verification of circuit analysis concepts including Kirchhoff's Laws, Thevenin's Theorem, maximum power transfer and superposition. 1 laboratory. Formerly EE 241.

EE 2261 Introduction to C Programming with a Hardware Emphasis (1 unit)

Term Typically Offered: F

Recommended: CPE/CSC 101 or CSC 1001.

Introduction to the C programming language with an emphasis on microprocessor applications. Input/Output interfacing project to external components. 1 laboratory. Formerly EE 261.

EE 2262 Object-Oriented Programming with a Hardware Emphasis (1 unit)

Term Typically Offered: SP

Prerequisite: CPE/CSC 101 or CSC 1001.

Introduction to objected-oriented programming languages with an emphasis on microprocessor applications including measurement automation. 1 laboratory. Formerly EE 262.

EE 2270 Special Topics (1-4 units)

Term Typically Offered: TBD

Prerequisite: Consent of instructor.

Directed group study of special topics. The Class Schedule will list topic selected. Repeatable up to 8 units. 1 to 4 lectures. Formerly EE 270.

EE 2271 Special Laboratory (1-2 units)

Term Typically Offered: SP

Prerequisite: Consent of instructor.

Directed group laboratory study of special topics. The Class Schedule will list topic selected. Repeatable up to 4 units. 1 to 2 laboratories. Formerly EE 271.

EE 2328 Signals and Systems (4 units)

Term Typically Offered: F, SP

Prerequisite: One of the following: EE 201, EE 211, EE 2201, or EE 2211. Corequisite: One of the following: MATH 242, MATH 244, MATH 2341, or MATH 2343.

Description, classification, modeling, and analysis of continuous-time and discrete-time signals and systems. Convolution, Fourier series, Fourier transforms, Laplace transform, and z transform; and their application to the analysis of linear, time-invariant (LTI) systems. Introduction to sampling theory and digital filters. Course may be offered in classroom-based or online format. 3 lectures, 1 laboratory. EE 2328 is equivalent to CPE/EE 328, CPE/EE 368, CPE/EE 327, and CPE/EE 367, students may not earn credit for EE 2328 if they have earned credit for CPE/EE 328, CPE/EE 368, CPE/EE 327, and CPE/EE 367.

EE 3255 Electric Machines and Power Systems (3 units)

Term Typically Offered: F, SP

Prerequisite: One of the following: EE 201, EE 212, EE 2201, EE 2212, or EE 2115; and EE 241, EE 2241, or EE 2115L. Concurrent: EE 3255L.

Fundamentals of electromechanical energy conversion and power systems, power generation, transmission and distribution, Magnetic circuits, and electromagnetic devices. Modeling transmission lines, transformers, and induction and synchronous machines. Power system analysis tools include per-unit representation, single-line diagrams, efficiency, and voltage regulation. 3 lectures. Replaced EE 255.

EE 3255L Electric Machines and Power Systems Laboratory (1 unit)

Term Typically Offered: F, SP

Concurrent: EE 3255.

Measurements, parameter estimation, and operation of rotating machines and transformers. Single- and three-phase power measurements; active and reactive power measurements and compensation; transmission line models, power-flow software, and maximum power transfer. 1 laboratory. Replaced EE 295.

EE 3302 Classical Control Systems (3 units)

Term Typically Offered: F, SP

Prerequisite: EE 228, EE 215, or EE 2328. Concurrent: EE 3302L.

Feedback control systems. System modeling. Transfer functions and state space models of dynamic systems. Graphical system representations. System time response and stability analysis, including root locus. Frequency response methods. Compensation techniques. 3 lectures. Formerly EE 302.

EE 3302L Classical Control Systems Laboratory (1 unit)

Term Typically Offered: F, SP

Concurrent: EE 3302.

Laboratory work pertaining to classical control systems, including servo control, transient and frequency responses, stability, and computer-aided analysis of control systems. 1 laboratory. Formerly EE 342.

EE 3306 Electronics I (3 units)

Term Typically Offered: F, SP

Prerequisite: EE 211 or EE 2211. Concurrent: EE 3306L.

Electronic circuits. Terminal characteristics, circuit theory, and applications of diodes and transistors. Physics, internal structure and function of semiconductor devices. Digital circuits including inverters, transmission gates, combinational logic gates, and memory elements. Emphasis on contemporary CMOS VLSI. 3 lectures. Formerly EE 306.

EE 3306L Electronics Laboratory I (1 unit)

Term Typically Offered: F, SP

Concurrent: EE 3306.

Experimental determination of semiconductor device characteristics and models. Design, implementation, and test of diode, BJT, and MOSFET circuits including amplifiers and digital logic gates and memory elements. 1 laboratory. Formerly EE 346.

EE 3308 Electronics II (3 units)

Term Typically Offered: F, SP

Prerequisite: EE 306 or EE 3306; and EE 346 or EE 3306L. Concurrent: EE 3308L. Corequisite: EE 302 or EE 3302; and EE 342 or EE 3302L.

Analysis, design, and simulation of analog electronics including amplifiers, op-amps, and oscillators. Application of positive and negative feedback, transistor models, and computer-based simulations. 3 lectures. Formerly EE 308.

EE 3308L Electronics Laboratory II (1 unit)

Term Typically Offered: F, SP

Concurrent: EE 3308.

Design, construction, and testing of analog electronics including amplifiers, op-amps, and oscillators. Application of positive and negative feedback, transistor models, computer-based simulations, and measurement-based verification. 1 laboratory. Formerly EE 348.

EE 3322 Microcontrollers for Everyone (4 units)

Term Typically Offered: F, SP

2026-28 or later: Upper-Div GE Area 2/5

2020-26 catalogs: Upper-Div GE Area B

Prerequisite: Junior standing; completion of GE Area 1 with grades of C- or better (GE Area A for the 2020-26 catalogs); and completion of GE Area 2 with a grade of C- or better (GE Area B4 for the 2020-26 catalogs).

Microcontroller history and computer systems overview. Introduction to basic electrical circuits and computer programming concepts. Course may be offered in classroom-based or online format. 3 lectures, 1 laboratory. Fulfills GE Areas Upper-Division 2 or Upper-Division 5 (GE Area Upper-Division B for students on the 2020-26 catalogs). Formerly EE 322.

EE 3329 Cyber-Physical Systems (4 units)

Term Typically Offered: F, SP

Prerequisite: EE 306; or CPE 2300, CPE 2301, and EE 3306.

Top-down design, implementation, and testing of microcontroller-based systems. Integration of peripheral devices, including sensors and actuators, and hardware-software co-design. Programming to configure microcontroller functions and implement processing algorithms. Advanced electronic design considerations including power consumption and signal integrity/conditioning. Engineering ethics. Course may be offered in classroom-based or online format. 3 lectures, 1 laboratory. Formerly CPE/EE 329.

EE 3335 Electromagnetic Fields and Transmission (3 units)

Term Typically Offered: F, SP

Prerequisite: EE 211 or EE 2211; and MATH 241 or MATH 2263. Concurrent: EE 3335L.

Maxwell's equations in integral and point form. Force Equations. Plane wave propagation in free space. Static and AC electric and magnetic fields. Wave propagation in materials. Reflection and transmission of waves in transmission lines and at planar boundaries. Waveguides. Antennas. 3 lectures. Formerly EE 335.

EE 3335L Electromagnetic Fields and Transmission Laboratory (1 unit)

Term Typically Offered: F, SP

Concurrent: EE 3335.

Transmission line and electronic component measurements at microwave frequencies. Response to pulse excitation using time-domain techniques and sinusoidal excitation using frequency-domain techniques. Applications of the Smith Chart, Vector Network Analyzers (VNA) and computer-aided design tools in transmission line problems. 1 laboratory. Formerly EE 375.

EE 4314 Communication Systems (3 units)

Term Typically Offered: F, SP

Prerequisite: EE 335 or EE 3335. Concurrent: EE 4314L. Corequisite: EE 308 or EE 3308; and STAT 350 or STAT 3310.

Design and analysis of digital and analog wireless and wireline electronic communication systems. Analog modulation, random processes and noise, sampling theorem, Shannon's theorem, digital communications (BPSK, QPSK, QAM) and multiplexing, BER, link budget, communication system components, and networking. Course may be offered in classroom-based or online format. 3 lectures. Formerly EE 314.

EE 4314L Communication Systems Laboratory (1 unit)

Term Typically Offered: F, SP

Concurrent: EE 4314.

Design and analysis of digital wireless and wireline electronic communication systems. Simulation of communication system in CAD. Construction and characterization of AM, FM, BPSK and QAM communication links using SDRs. Design, fabrication and test of a communication system. 1 laboratory.

EE 4400 Special Problems (1-4 units)

Term Typically Offered: F, SP

Prerequisite: Consent of department chair.

Individual investigation, research, studies, or surveys of special problems. Repeatable up to 4 units. Formerly EE 400.

EE 4406 Power System Analysis I (3 units)

Term Typically Offered: F

Prerequisite: EE 255 or EE 3255.

Overview of power system equipment. Analysis of transmission line models. Calculation of single-phase and three-phase power circuits using per unit method. Steady state operation and power flow analysis of transmission lines. Analysis of faults in power systems. 3 lectures. Formerly EE 406.

EE 4407 Power System Analysis II (3 units)

Term Typically Offered: TBD

Prerequisite: EE 406 or EE 4406.

Introduction to power system protection. Power system stability analysis. Power system controls. Power system economic dispatch and optimization. Transient operation of transmission lines. Use of commercially available software. 2 lectures, 1 laboratory. Formerly EE 407.

EE 4410 Fundamentals of Power Electronics (3 units)

Term Typically Offered: F

Prerequisite: EE 306 or EE 3306; and EE 346 or EE 3306L.

Introduction to power electronic converters and power semiconductor devices. Steady state analysis, performance study, and design of uncontrolled and controlled rectifiers, non-isolated and isolated DC-DC converters, AC voltage controllers, and switched mode inverters. Use of commercially available software. 2 lectures, 1 laboratory. Formerly EE 410.

EE 4412 Advanced Analog and Mixed-Signal Electronics (2 units)

Term Typically Offered: F

Prerequisite: EE 308 or EE 3308; and EE 348 or EE 3308L. Recommended: STAT 350 or STAT 3310; and EE 4452.

Analysis and design of electronic systems with an emphasis on noise and distortion. Performance metrics: NF, SNR, THD, IMD, P1dB, L(f), and jitter. Overview of high-performance circuit topologies such as low-noise amplifiers, oversampling data converters, phase-lock loops, and frequency synthesizers. 2 lectures. Formerly EE 412.

EE 4416 Digital Communication Systems (3 units)

Term Typically Offered: SP

Prerequisite: EE 314 or EE 4314. Recommended: EE 456 or EE 4456.

Modern communication systems. Analysis of packetization, statistical delay models, multiaccess techniques and optimal network routing. Analysis and design of data-carrying signals including baseband pulse shaping and bandpass modulation schemes. Spread spectrum and orthogonality-based encoding. Course may be offered in classroom-based or online format. 3 lectures. Formerly EE 416.

EE 4417 Electric Machines (3 units)

Term Typically Offered: F

Prerequisite: EE 255 or EE 3255; and EE 295 or EE 3255L.

Analyze mechanical torque development, Apply Space Vector and Park and Clark Transformation on rotating machines, Induction Generators, DC brushed and brushless motors, and generators. The effect of VFD higher harmonic currents on Induction motors. Magnetic actuators and dynamometers. 2 lectures, 1 laboratory. Formerly EE 417.

EE 4418 Photonic Component and System Engineering (3 units)

Term Typically Offered: SP

Prerequisite: EE 335 or EE 3335. Concurrent: EE 4418L.

Modern photonic component and systems design. Theory of operation for components such as optical waveguides, lasers, LEDs, lenses, diffraction gratings, mirrors, modulators, optical filters, and photoreceivers. System-level coverage of fiber-optic communication systems, industrial, biomedical and scientific applications of photonics. 3 lectures. Formerly EE 418.

EE 4418L Photonic Engineering Laboratory (1 unit)

Term Typically Offered: SP

Concurrent: EE 4418.

Experimental Investigation of photonic components and systems. Ray tracing through lenses, mirrors, diffraction gratings and prisms followed by optical bench experiments. Simulation, design and characterization of optical waveguides, lasers, LEDs, modulators, optical filters, and photoreceivers, and fiber-optic communication systems. 1 laboratory. Formerly EE 458.

EE 4419 Digital Signal Processing (3 units)

Term Typically Offered: F

Prerequisite: EE 327, EE 328, or EE 2328. Corequisite: One of the following: EE 329, EE 3329, CPE 316, or CPE 3160.

Practical signal sampling and quantization system design. Discrete and Fast Fourier Transform signal processing including convolution, signal correlation, and spectral analysis. Analysis and design of FIR and IIR digital filters with real-time implementation in an embedded DSP processor. 2 lectures, 1 laboratory. Formerly EE 419.

EE 4420 Sustainable Energy Generation (3 units)

Term Typically Offered: TBD

Prerequisite: One of the following: BRAE 216, BRAE 2216, EE 255, EE 3255, or EE 2115.

Electrical engineering aspects of sustainable energy conversion, including wind, photovoltaic, and ocean power generation and usage. Power control, processing, and quality for grid-connected and stand-alone systems. Distribution and storage of electric energy. Distributed generation. 2 lectures, 1 laboratory. Formerly EE 420.

EE 4422 Polymer Electronics Laboratory (1 unit)

Term Typically Offered: SP

Prerequisite: One of the following: EE 346, EE 3306L, MATE 340, or MATE 3340.

Experimental procedures in polymer electronics. Investigation of the characteristics of a polymer electronic device. 1 laboratory. Formerly EE/PHYS 422.

EE 4425L Signal Integrity Electronics and Test Automation Laboratory (1 unit)

Term Typically Offered: SP

Concurrent: EE 4425.

Electronic filter simulation, build, and test from audio to millimeter-wave frequencies. Design and measure high-speed printed circuit board assemblies to demonstrate signal integrity concepts. Electromagnetic compatibility and susceptibility simulations and measurements. Automation of high-speed electronic measurement systems. 1 laboratory.

EE 4425 Signal Integrity Electronics and Test Automation (3 units)

Term Typically Offered: SP

Prerequisite: EE 335 or EE 3335. Concurrent: EE 4425L.

High-speed analog and digital electronics design with an emphasis on circuit-board implementation. Intentional and unintentional passive and active filtering of signals. High-speed measurements and test automation techniques. Electromagnetic Interference and susceptibility. 3 lectures. Formerly EE 425.

EE 4431 Computer-Aided Design of VLSI Devices (3 units)

Term Typically Offered: SP

Prerequisite: EE 306 or EE 3306. Recommended: EE 308 or EE 3308.

Design of VLSI integrated circuits using state-of-the-art CAD software. Complete design process for digital, analog, and mixed signal integrated electronics. Major multi-week electronic chip design project. 2 lectures, 1 laboratory. Formerly CPE 441/EE 431.

EE 4433 Magnetic Apparatus Design (3 units)

Term Typically Offered: TBD

Prerequisite: EE 255 or EE 3255.

Magnetic properties and circuits in power converters. Design of inductors and transformers without and with air gaps. Core selection, window utilization factor, efficiency, regulation, and temperature rise analysis. Planar magnetics, and non-linear model of magnetic components. 2 lectures, 1 laboratory. Formerly EE 433.

EE 4434 Transportation Electrification and Energy Storage Systems (3 units)

Term Typically Offered: TBD

Prerequisite: EE 212 or EE 2212.

Effects of electrification of transportation systems on the transportation industry and power systems. Implications of the shift on the electric power system, electric vehicle technology such as charging technology and infrastructure, passenger and commercial vehicles, trains and aviation. 3 lectures. Formerly BRAE/EE 434.

EE 4435 Industrial Power Control and Automation (1 unit)

Term Typically Offered: SP

Prerequisite: EE 225 or EE 3255; and EE 302 or EE 3302.

Programmable automation controllers including custom developed functions, electrical hardware interfaces, communications networking to intelligent electronic devices, and machine operator interface terminals. Applications of industrial power control and automation systems including protection equipment, motor controllers, renewable energy, and sensors. 1 laboratory. Formerly EE 435.

EE 4440 Wireless Communications (3 units)

Term Typically Offered: TBD

Prerequisite: EE 335 or EE 3335. Concurrent: EE 4440L.

Wireless microwave system design and analysis. RF transmission lines, microwave networks, receiver design, modulation techniques, and mixer characterization and realizations. Noise and distortion, RF oscillators and frequency synthesizers, filter design. Radiating systems and electromagnetic wave propagation, microwave amplifier design. 3 lectures. Formerly EE 440.

EE 4440L Wireless Communications Laboratory (1 unit)

Term Typically Offered: TBD

Concurrent: EE 4440.

Experimental methods of wireless microwave system design and analysis. Transmitter and receiver design, modulation techniques, and mixer characterization and realizations. Noise and distortion, RF oscillators and frequency synthesizers, filter design. Radiating systems and electromagnetic wave propagation, microwave amplifier design. 1 laboratory. Formerly EE 480.

EE 4450 Solar Photovoltaic System Engineering I (3 units)

Term Typically Offered: F

Prerequisite: One of the following: EE 212, EE 2212, BRAE 216, or BRAE 2216.

Engineering principles, design, and installation of solar photovoltaic power systems including grid-tie and off-grid systems. Photonic energy conversion, solar module engineering, solar power electronics, photovoltaic site planning, mechanical and structural considerations, permit processes, government incentives, and analysis of financial and investment issues. Field trip may be required. 2 lectures, 1 laboratory. Formerly BRAE/EE/HNRS 450.

EE 4452 Advanced Analog and Mixed-Signal Electronics Laboratory (1 unit)

Term Typically Offered: F

Prerequisite: EE 308 or EE 3308; and EE 348 or EE 3308L. Corequisite: EE 4412. Recommended: STAT 350 or STAT 3310.

Project-based advanced laboratory study of noise sources, transducer interface circuits, data converters, voltage-controlled oscillators (VCO), phase detectors, and phase-locked loops (PLL). Formal experiments, computer simulations, and data processing, teamwork. 1 laboratory. Formerly EE 452.

EE 4455 Design of Fault-Tolerant Systems (4 units)

Term Typically Offered: F

Prerequisite: One of the following: CPE 316, CPE 3160, CPE/EE 329, or EE 3329. Recommended: One of the following: STAT 350, STAT 3310, STAT 312, or STAT 3210.

Hardware and software fault tolerance concepts: fault models; coding in computer systems; module and system-level fault detection mechanisms; reconfiguration techniques for general purpose processors and ASICs; software fault tolerance techniques such as recovery blocks, N-version programming, and checkpointing and recovery. Course may be offered in classroom-based, online, or hybrid format. 3 lectures, 1 laboratory. Crosslisted as CPE/EE 4455. Formerly CPE/EE 446.

EE 4456 Modern Communication Systems Laboratory (1 unit)

Term Typically Offered: TBD

Prerequisite: EE 314 or EE 4314. Corequisite: EE 416 or EE 4416.

Design and analysis of modern communication systems. Simulation of communication system in CAD. Construction and characterization of modern communication systems for transmission through lossy and noisy channels. 1 laboratory. Formerly EE 456.

EE 4459 Electrical Engineering Fundamentals of Engineering Exam (1 unit)

Term Typically Offered: F, SP

Prerequisite: Senior standing. Recommended: EE 308 or EE 3308.

Review of 1st year, 2nd year and 3rd year of the Electrical Engineering Curriculum. Preparation to pass the California Board for Professional Engineers Fundamentals of Engineering examination for Electrical Engineers. Course may be offered in classroom-based or online format. 1 activity.

EE 4461 Senior Project I (1 unit)

Term Typically Offered: F, SP

Prerequisite: Senior standing; and EE 302 or EE 3302. Concurrent: EE 4463 or EE 4465. Corequisite: EE 308 or EE 3308; EE 255 or EE 3255; EE 329 or EE 3329; and EE 335 or EE 3335.

Introduction to system design and project management. Stakeholders, customer requirements, and engineering specifications. Top-down design addressing an open-ended technical challenge; functional decomposition, concept generation, and structured decision-making. Considerations of embodied energy, design for the environment, verification, project planning, and teamwork. 1 lecture. Formerly EE 461.

EE 4462 Senior Project II (1 unit)

Term Typically Offered: F, SP

Prerequisite: EE 461 or EE 4461. Concurrent: EE 4464 or EE 4466.

Global perspectives. Diversity of work teams and elements of inclusion. Internationalization and culture. Product life-cycle and sustainability. Ethics frameworks, professional ethics, code of ethics. Addressing ethical dilemmas as a process. 1 lecture. Formerly EE 462.

EE 4463 Senior Project Design Laboratory I (1 unit)

Term Typically Offered: F, SP

Concurrent: EE 4461.

Initiation and planning of a team project to address an open-ended design challenge. Problem definition, concept generation, feasibility, and design analysis. Professional skills: communication, teamwork, project management. 1 laboratory. Formerly EE 463.

EE 4464 Senior Project Design Laboratory II (1 unit)

Term Typically Offered: F, SP

Prerequisite: EE 461 or EE 4461; and EE 463 or EE 4463. Concurrent: EE 4462.

Execution and close out of a team design project. Product realization, including material procurement, prototyping, design verification, and validation. Professional skills: communication, teamwork, project management. 1 laboratory. Formerly EE 464.

EE 4465 Senior Design: Individual Project I (1 unit)

Term Typically Offered: F, SP

Prerequisite: Consent of instructor. Concurrent: EE 4461.

Individual project activity under faculty supervision. Initiation and planning of a project to address an open-ended design challenge. Problem definition, concept generation, feasibility, and design analysis. Professional skills: communication and project management.

EE 4466 Senior Design: Individual Project II (1 unit)

Term Typically Offered: F, SP

Prerequisite: EE 4465. Concurrent: EE 4462.

Individual project activity under faculty supervision. Execution and close out of a design project. Product realization, including material procurement, prototyping, design verification, and validation. Professional skills: communication, and project management. 1 supervisory.

EE 4470 Special Advanced Topics (1-4 units)

Term Typically Offered: TBD

Prerequisite: Consent of instructor.

Directed group study of special topics for advanced students. The Class Schedule will list topic selected. Repeatable up to 8 units. Course may be offered in classroom-based, online, or hybrid format. 1 to 4 lectures. Formerly EE 470.

EE 4471 Special Advanced Laboratory (1-2 units)

Term Typically Offered: TBD

Prerequisite: Consent of instructor.

Directed group laboratory study of special topics for advanced students. The Class Schedule will list topic selected. Repeatable up to 8 units. 1 to 2 laboratories. Formerly EE 471.

EE 4485 Cooperative Education Experience (1-2 units)

Term Typically Offered: F, SP, SU

CR/NC

Prerequisite: Sophomore standing and consent of instructor.

Work experience in business, industry, government, and other areas of student career interest. Positions are paid and may require relocation and registration in course for two consecutive semesters. Formal report and evaluation by work supervisor required. Repeatable up to 4 units. Credit/No Credit grading only. Formerly EE 493.

EE 4495 Cooperative Education Experience (6-12 units)

Term Typically Offered: F, SP, SU

CR/NC

Prerequisite: Sophomore standing and consent of instructor.

Work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually may relocation and registration in course for two consecutive semesters. Evaluation by work supervisor required. Repeatable up to 24 units. Credit/No Credit grading only. Formerly EE 494.

EE 4528 Digital Image Processing (4 units)

Term Typically Offered: F

Prerequisite: EE 327, EE 328, or EE 2328.

Image processing and interpretation by computer. Emphasis on current applications with real images used in programming assignments. Concepts include intensity transformation, histogram equalization, spatial filtering, frequency-domain filtering, image restoration, wavelet and other image transforms, image compression, morphological operations, object recognition. 3 lectures, 1 laboratory. Formerly EE 528.

EE 5344 Phased Array Antennas (3 units)

Term Typically Offered: F

Prerequisite: EE 335, EE 3335, or graduate standing.

Phased arrays antennas, including array factor fundamentals, mutual coupling and array element patterns, analog and digital beamforming, array system considerations, and new phased array technologies. Course may be offered in classroom-based or online format. 3 lectures.

EE 5424 Principles of Remote Sensing and Radar (3 units)

Term Typically Offered: SP

Prerequisite: EE 2328 or graduate standing.

Remote sensing and radar systems. Radiation characteristics, sensor technology, platforms, satellite systems, and system architecture design tradeoffs. Signal processing techniques for transmitting and receiving sub-systems. Interpretation of sensed data for various applications. 2 lectures, 1 laboratory.

EE 5428 Computer Vision (4 units)

Term Typically Offered: SP

Prerequisite: EE 2328 or graduate standing.

Concepts of 2D and 3D computer vision: image formation, camera imaging geometry, feature detection and matching, segmentation and clustering, stereo vision, image classification, scene understanding. 3 lectures, 1 laboratory.

EE 5500 Individual Study (1-3 units)

Term Typically Offered: F, SP

Prerequisite: Consent of department chair.

Advanced study planned and completed under the direction of a member of the department faculty. Open only to graduate students who have demonstrated ability to do independent work. Enrollment by petition. Repeatable up to 4 units. Formerly EE 500.

EE 5502 Microwave and Millimeter Wave Device and System Electronics (4 units)

Term Typically Offered: TBD

Prerequisite: EE 306 or EE 3306 and EE 335 or EE 3335; or graduate standing.

Passive and active microwave/millimeter wave systems theory, design and project construction. Theory of operation and modelling of high-frequency semiconductor devices. Design, fabricate, and test microwave systems utilizing splitters, filters, mixers, detectors, oscillators, modulators, and amplifiers. Course may be offered in classroom-based or online format. 3 lectures, 1 laboratory. Formerly EE 502.

EE 5504 Software Defined Radio (4 units)

Term Typically Offered: F

Prerequisite: EE 314, EE 4314, or graduate standing.

Software defined radios, including architectures of software defined radio receivers and transmitters, design principles and trade-offs, signal processing techniques, and applications of the technologies, such as cognitive radio. Course may be offered in classroom-based or online format. 3 lectures, 1 laboratory. Formerly EE 504.

EE 5509 Computational Intelligence (4 units)

Term Typically Offered: F

Prerequisite: EE 2328 or graduate standing.

Theory, design, and applications of biologically motivated computational paradigms, including artificial neural networks, evolutionary computing, and hybrid intelligent systems. Course may be offered in classroom-based or online format. 3 lectures, 1 laboratory. Formerly EE 509.

EE 5510 Advanced Power Electronics (3 units)

Term Typically Offered: SP

Prerequisite: EE 410, EE 4410, or graduate standing.

Steady-state thermal analysis of power devices. Switching trajectory, switching losses, and Safe Operating Area of power devices. Analysis and design of snubber circuits. Steady-state analysis and operation of DC-DC converter topologies. Compensator designs in DC-DC converters. 3 lectures. Formerly EE 527.

EE 5511 Advanced Electric Machines and Design (3 units)

Term Typically Offered: TBD

Prerequisite: EE 255, EE 3255, or graduate standing.

New electric machines technologies, analysis, and design of advanced electric machines using computer-aided software programs, including Finite Element Magnetism Modeling. 2 lectures, 1 laboratory. Formerly EE 511.

EE 5512 Advanced Control Techniques in Modern Power Systems (3 units)

Term Typically Offered: F

Prerequisite: EE 302 or EE 3302 and EE 255 or EE 3255; or graduate standing.

In-depth exploration of electric machine modeling and control. Control techniques applied in power generation and distribution systems, renewable energy systems, electric vehicles and microgrids. 3 lectures.

EE 5513 Modern Control Systems (4 units)

Term Typically Offered: F

Prerequisite: EE 302, EE 3302, or graduate standing.

Modern control theory. Concepts include theory and implementation of digital controls, sampled-data systems, state space models, controllability, observability, and pole placement. Course may be offered in classroom-based or online format. 3 lectures, 1 laboratory.

EE 5514 Advanced Modern Control Systems (4 units)

Term Typically Offered: SP

Prerequisite: EE 302, EE 3302, or graduate standing. Recommended: EE 5513.

Advanced subjects in modern control theory. Concepts may include linear vector space, linear quadratic optimal control and time optimal control, nonlinear system analysis, as well as adaptive and fuzzy logic systems. Course may be offered in classroom-based or online format. 4 lectures.

EE 5515 Advanced Digital Signal Processing (3 units)

Term Typically Offered: SP

Prerequisite: EE 314, EE 2328, or graduate standing.

Advanced subjects in digital filter design and implementation. Concepts may include signal analysis via spectral estimation, multi-rate digital signal processing, adaptive filters, quantization effect on filter coefficients, and wavelet transform. Course may be offered in classroom-based or online format. 3 lectures.

EE 5517 Data Analytics for Cyber-Physical Systems (3 units)

Term Typically Offered: F

Prerequisite: EE 2328, EE 3329, or graduate standing.

Challenges and opportunities associated with analyzing large and complex datasets generated by sensors and other devices in cyber-physical systems, with a focus on real-time analytics, machine learning, and applications. 3 lectures.

EE 5518 Power System Protection (3 units)

Term Typically Offered: SP

Prerequisite: EE 406, EE 4406, or graduate standing.

Analysis of faults in electric power devices and systems. Design reliable protection systems to detect and mitigate electric device and system faults. Smart relays for protection and condition monitoring. 2 lectures, 1 laboratory. Formerly EE 518.

EE 5519 Electric Power Distribution and Microgrids (3 units)

Term Typically Offered: SP

Prerequisite: EE 255, EE 3255, or graduate standing.

Principles of electric power distribution systems and their reliability, voltage regulation, and line compensations. Controllers, Supervisory Control and Data Acquisition (SCADA), single-phase and three-phase transformers in distribution systems. Distributed energy resources and microgrids. 3 lectures.

EE 5520 Advanced Solar-Photovoltaic Systems Design (3 units)

Term Typically Offered: SP

Prerequisite: EE 450, EE 4450, or graduate standing.

Solar resource. Solar cell theory. Photovoltaic module and array design. Power processing circuits and systems. MPPT Algorithms. Energy storage options. Life Cycle Assessment. Recycling of Solar PV equipment. Economic, policy and sustainability issues. Field trip may be required. 3 seminars. Formerly EE 520.

EE 5524 Solid State Electronics (2 units)

Term Typically Offered: TBD

Prerequisite: EE 306, EE 3306, or graduate standing. Recommended: EE 544 or EE 5544.

Physical theory of solid-state devices. Properties of metal-semiconductor junctions and p-n junctions. Derivation of properties of diodes, transistors, and four-layer devices from basic physical and mathematical considerations. 2 lectures. Formerly EE 524.

EE 5525 Stochastic Processes (3 units)

Term Typically Offered: F

Prerequisite: STAT 350, STAT 3310, or graduate standing.

Probability and stochastic processes used in random signal analysis. Response of linear systems to random inputs. Auto-correlation and power spectral densities. Applications in signal processing using the discrete Kalman filter. 3 lectures. Formerly EE 525.

EE 5526 Advanced Digital Communications (4 units)

Term Typically Offered: F

Prerequisite: EE 416, EE 4416, or graduate standing.

Vector space representation of signals. Optimum receiver principles. Information theory. Error correction coding from basics to capacity-approaching codes. Course may be offered in classroom-based or online format. 3 lectures, 1 laboratory. Formerly EE 526.

EE 5530 Advanced Photonic Systems (4 units)

Term Typically Offered: TBD

Prerequisite: EE 335, EE 3335, or graduate standing.

Design, implementation, and characterization of advanced photonic systems including holography, imaging systems, photonic sensing, spectroscopy, nonlinear systems, photonic communication systems, optical coherence tomography (OCT), and light detection and ranging systems. 3 lectures, 1 laboratory. Formerly EE 530.

EE 5531 Advanced VLSI Design and Validation (3 units)

Term Typically Offered: TBD

Prerequisite: EE 431, EE 4431, or graduate standing. Recommended: EE 532 or EE 5532.

Design, optimize, and validate a complete very large scale integration (VLSI) design with digital signal processing (DSP), controls, and sensor inputs. Improve VLSI design performance, power and area, built-in security features, power management and test features. Develop formal performance verification plan. 2 lectures, 1 laboratory. Formerly CPE 541/EE 531.

EE 5532 VLSI Test Laboratory (1 unit)

Term Typically Offered: TBD

Prerequisite: EE 306, EE 3306, or graduate standing.

Characterization, testing and documentation of a fabricated very large scale integration (VLSI) electronic chip. Validation activities include Digital Signal Processing, controls, and sensor input/outputs using state-of-the-art chip test equipment. Generate automated test reports and databases. 1 laboratory. Formerly CPE/EE 532.

EE 5533 Antennas (4 units)

Term Typically Offered: SP

Prerequisite: EE 335, EE 3335, or graduate standing.

Principles of antenna theory. Antenna parameters, radiation integrals. Duality and reciprocity theorems. Wire antennas. Antenna arrays. Traveling wave antennas. Broadband and frequency independent antennas. Aperture and reflector antennas. Microstrip antennas. Antenna design. 3 lectures, 1 laboratory. Formerly EE 533.

EE 5535 Utility Applications of Power Electronics and Power Quality (3 units)

Term Typically Offered: SP

Prerequisite: EE 410, EE 4410, or graduate standing.

Overview of power electronics and power quality in the context of grid-scale applications. Application areas include HVDC, FACTS controllers, renewable energy, energy storage, and grid-connected electric vehicles. Power quality issues, indices, standards, and mitigation techniques. 3 lectures.

EE 5541 Advanced Microwave and Millimeter-Wave Laboratory (1 unit)

Term Typically Offered: TBD

Prerequisite: EE 335, EE 3335, or graduate standing.

Projects in the microwave and millimeter-wave frequency range. Experimental measurement techniques using advanced electronic test and measurement equipment including vector network analyzers and vector signal analyzers/generators. Advanced computer-aided design simulations for high-frequency designs. Course may be offered in classroom-based or online format. 1 laboratory. Formerly EE 541.

EE 5544 Solid-state Electronics Laboratory (1 unit)

Term Typically Offered: TBD

Prerequisite: EE 306, EE 3306, or graduate standing. Recommended: EE 524 or EE 5524.

Experimental procedures in solid-state electronics and integrated circuits. Investigation and improvement of the characteristics of solid-state electronic devices and integrated circuits. 1 laboratory. Formerly EE 544.

EE 5563 Graduate Seminar (1 unit)

Term Typically Offered: F, SP

CR/NC

Prerequisite: Graduate standing.

Current developments in the fields of electrical and electronic engineering. Participation by students, faculty, and guest lecturers. Preparation for conducting research through discussions, selected readings, and student presentations. Open to graduate students with a background in electrical or electronic engineering. Repeatable up to 2 units. Credit/No Credit grading only. 1 seminar. Formerly EE 563.

EE 5570 Special Advanced Topics (1-4 units)

Term Typically Offered: TBD

Prerequisite: Graduate standing and consent of instructor.

Directed group study of special topics for advanced students. The Class Schedule will list topic selected. Repeatable up to 8 units. Course may be offered in classroom-based, online, or hybrid format. 1 to 4 lectures. Formerly EE 570.

EE 5571 Special Advanced Laboratory (1-2 units)

Term Typically Offered: TBD

Prerequisite: Graduate standing and consent of instructor.

Directed group laboratory study of special topics for advanced students. The Class Schedule will list topic selected. Repeatable up to 4 units. 1 to 2 laboratories. Formerly EE 571.

EE 5594 Professional Engineer Examination (1 unit)

Term Typically Offered: F

CR/NC

Prerequisite: Consent of instructor.

Preparations to pass the Electrical Engineering Professional Engineering examination administered by the National Council of Examiners for Engineering and Surveying (NCEES) organization and sponsored by the California Board of Professional Engineers. Credit/No Credit grading only. 1 activity.

EE 5595 Cooperative Education Experience (1-2 units)

Term Typically Offered: F, SP, SU

CR/NC

Prerequisite: Graduate standing and consent of instructor.

Advanced study analysis and full-time work experience in student's career field; current innovations, practices, and problems in Electrical Engineering. Must have demonstrated ability to do independent work and research in career field. A fully-developed formal report and evaluation by work supervisor required. Repeatable up to 4 units. Credit/No Credit grading only. Formerly EE 595.

EE 5597 Comprehensive Examination (1 unit)

Term Typically Offered: F, SP

CR/NC

Prerequisite: Graduate standing and consent of instructor.

Comprehensive assessment for a non-thesis master's student. Students must enroll in this course in their final semester to fulfill culminating experience. Under the guidance of instructors, demonstrate mastery and integrated electrical engineering knowledge at the graduate level. Credit/No Credit grading only.

EE 5599 Thesis (1-5 units)

Term Typically Offered: F, SP

Prerequisite: Graduate standing and consent of instructor.

Systematic study of a significant problem under faculty supervision. Both a written thesis and an oral defense are required. Repeatable up to 6 units. Formerly EE 599.