

ELECTRICAL ENGINEERING (ELEC_ENG)

ELEC_ENG 100-0 Electrons, Photons, and Bits: Adventures in Electrical and Computer Engineering (1 Unit) Introduction to contemporary topics in electrical engineering (5 weeks) and computer engineering (5 weeks) via lectures, demonstrations, and lab tours. No exams, but two in-depth term papers are required: the first on an electrical engineering topic reviewed during the first half of the course, and the second on a computer engineering topic reviewed during the second half of the course.

ELEC_ENG 195-0 Special Topics in Electrical Engineering (1 Unit) Topics suggested by students or faculty and approved by the department.

ELEC_ENG 202-0 Introduction to Electrical Engineering (1 Unit) Introduction to fundamental concepts and applications of electrical engineering. Topics include: circuit analysis from dc resistive networks to networks of impedances operating in the sinusoidal steady-state; circuit simplification and the Thevenin equivalent circuit; complex numbers and phasors; series and parallel inductor-capacitor resonance; simple analog filters; power transfer and impedance matching; op amps realizing active filters; signal spectra and the Fourier transform; signal sampling and aliasing; bandwidth and channel capacity; simple feedback and control systems; semiconductor electronics and devices including diodes, transistors, light-emitting diodes, and lasers.

ELEC_ENG 221-0 Fundamentals of Circuits (1 Unit) Fundamental concepts in electrical circuits; circuit analysis and network theorems; linearity and superposition; series/parallel combinations of R, L, and C circuits; sinusoidal forcing; complex frequency and Bode plots; mutual inductance and transformers; two port networks. Prerequisite: ELEC_ENG 202-0.

ELEC_ENG 222-0 Fundamentals of Signals & Systems (1 Unit) Comprehensive introduction to analysis of continuous and discrete-time signals and systems. Linear time-invariant systems, convolution. Fourier series representations of periodic signals. Continuous and discrete-time Fourier transforms. Laplace transform; z-transform. Prerequisite: ELEC_ENG 202-0.

ELEC_ENG 223-0 Fundamentals of Solid State Engineering (1 Unit) Crystalline state of matter; quantum phenomena and quantum mechanics; electrons in atoms, atoms in crystals, electrons in crystals; semiconductors; thermal properties of crystals, electrical properties of crystals and semiconductors; pn junction. Prerequisites: ELEC_ENG 202-0; PHYSICS 135-3; MATH 228-2.

ELEC_ENG 224-0 Fund of Electromagnetics & Photonics (1 Unit) Introduction to electromagnetic waves in electrical engineering. Topics include: analysis of transmission lines in the time domain and the sinusoidal steady-state; fundamentals of electrostatics and magnetostatics; Maxwell's equations for time-varying electromagnetic fields; plane electromagnetic wave propagation, reflection, and transmission at material interfaces; Poynting's theorem; introduction to fiber optics and photonics. Prerequisites: (ELEC_ENG 202-0 and ELEC_ENG 221-0 and PHYSICS 135-2 and MATH 228-2) or consent of instructor.

ELEC_ENG 225-0 Fundamentals of Electronics (1 Unit) Diode, BJT, and FET circuits; design using ideal operational amplifiers; feedback; frequency response; biasing; current sources and mirrors; small-signal analysis; design of operational amplifiers. Prerequisites: ELEC_ENG 221-0.

ELEC_ENG 250-0 Physical Electronics and Devices (1 Unit) The physical basis of electronic and optoelectronic devices and their application in analog and digital systems. Diodes, transistors, LEDs, photodetectors, and lasers are described, and their properties explored. Prerequisites: ELEC_ENG 221-0; PHYSICS 135-2.

ELEC_ENG 295-0 Special Topics in Electrical Engineering (1 Unit) Topics suggested by students or faculty and approved by the department.

ELEC_ENG 302-0 Probabilistic Systems (1 Unit) Introduction to probability theory and its applications. Axioms of probability, distributions, discrete and continuous random variables, conditional and joint distributions, correlation, limit laws, connection to statistics, and applications in engineering systems. Students may not receive credit for both ELEC_ENG 302-0 and any of the following: IEMS 302-0; MATH 310-1; MATH 311-1; MATH 314-0; MATH 385-0; STAT 320-1; STAT 383-0. Corequisite: MATH 228-2 or equivalent.

ELEC_ENG 307-0 Communications Systems (1 Unit) This course covers the fundamentals of modern communications. Specifically, this course explores design principles and performance considerations for communication systems, and provides insight into design challenges for next-generation communication systems and data networks. Prerequisites: ELEC_ENG 222-0, ELEC_ENG 302-0 or equivalent.

ELEC_ENG 308-0 Applied Electromagnetics and Photonics (1 Unit) Electromagnetic wave behavior and design of metallic, dielectric, and optical waveguides and antennas and antenna arrays. Electromagnetic wave fundamentals of wireless communications systems and radar techniques. Prerequisite: ELEC_ENG 224-0.

ELEC_ENG 326-0 Electronic System Design I (1 Unit) This fast-paced course will teach a student how to go from a project idea to a fully functional prototype implementation. This involves a printed circuit design using PCB CAD software, surface mount soldering, MCU programming, CAD design for 3D printing, and web design. This course has been approved as an Electrical Engineering Technical Elective to be included in the 2020-2021 Catalog. Current electrical engineering students can petition to use it as a technical elective. Prerequisite: Students must have completed (ELEC_ENG 225-0 and COMP_SCI 211-0), or MECH_ENG 333-0, or graduate standing, or instructor consent.

ELEC_ENG 327-0 Electronic System Design II: Project (1 Unit) This course puts to practice the knowledge gained in Electronic System Design I, and have students create a fully functional prototype implementation. This involves the same principles as in Electronic System Design I, but more independently, and with some design optimization. The course will also focus on team management and presentation skills, culminating in a project fair to the public. For a student with senior standing, this course can count towards the Design Degree Requirement in EE. Prerequisite: ELEC_ENG 326-0 or instructor consent.

ELEC_ENG 328-0 Information Theory & Learning (1 Unit) This course gives students analytical tools to quantify information, perform inference, and study the relationship of information and learning. The course covers information measures, the source and the channel coding theorems, statistical inference, and learning with neural networks. In particular, the course explores a common set of models and tools used by both machine learning and state-of-the-art data compression and error-control codes. This course is aimed at undergraduate students in engineering, science, mathematics, and computing. It expects familiarity

with undergraduate-level calculus, probability theory, and linear algebra.
Prerequisite: Basic probability theory (ELEC_ENG 302-0 or equivalent).

ELEC_ENG 331-0 Introduction to Computational Photography (1 Unit)

Fundamentals of digital imaging and modern camera architectures. Hands-on experience acquiring, characterizing, and manipulating data captured using a modern camera platform.
Prerequisite: COMP_SCI 150 or COMP_SCI 211 or Consent of Instructor.

ELEC_ENG 332-0 Introduction to Computer Vision (1 Unit)

Computer and biological vision systems, image formation, edge detection, image segmentation, texture, representation and analysis of two-dimensional geometric structures and of three-dimensional structures.
Prerequisites: COMP_SCI 212-0 or ELEC_ENG 302-0 or equivalent or graduate standing.

ELEC_ENG 333-0 Introduction to Communication Networks (1 Unit)

Data communication basics. Telephone, cellular, cable, and computer networks. Layered network architectures, models, and protocols. Switching, routing, flow control, and congestion control. Medium access control, ARQ, and local area networks. Queuing models and network performance analysis.
Prerequisite: ELEC_ENG 302-0 or equivalent.

ELEC_ENG 334-0 Fundamentals of Blockchains and Decentralization (1 Unit)

This course is partly an introduction to the fundamentals of blockchains and decentralized applications and partly a springboard toward deeper understanding and further exploration. The course explains how blockchains work; teaches the underlying fundamentals of distributed consensus; provides hands-on experience through computer assignments; and also touches upon economic and policy issues.
Prerequisites: COMP_SCI 212-0 or ELEC_ENG 302-0 or equivalent or graduate standing and basic programming skills.

ELEC_ENG 335-0 Deep Learning Foundations from Scratch (1 Unit)

The course covers the fundamentals of deep learning and numerical optimization, with many application examples.

ELEC_ENG 353-0 Digital Microelectronics (1 Unit)

Logic families, comparators, A/D and D/A converters, combinational systems, sequential systems, solid-state memory, largescale integrated circuits, and design of electronic systems.
Prerequisites: COMP_ENG 203-0, ELEC_ENG 225-0.

ELEC_ENG 359-0 Digital Signal Processing (1 Unit)

Discrete-time signals and systems. Discrete-time Fourier transform, z-transform, discrete Fourier transform, digital filters.
Prerequisite: ELEC_ENG 222-0.

ELEC_ENG 360-0 Introduction to Feedback Systems (1 Unit)

Linear feedback control systems, their physical behavior, dynamical analysis, and stability. Laplace transform, frequency spectrum, and root locus methods. System design and compensation using PID and lead-lag controllers. Digital implementations of analog controllers.
Prerequisite: ELEC_ENG 222-0 or MECH_ENG 390-0 or BMD_ENG 309-0 or equivalent.

ELEC_ENG 363-0 Digital Filtering (1 Unit)

Recursive and nonrecursive digital filters, decimation and interpolation, A/D and D/A conversion as digital filtering problems. Implementation of nonrecursive filters via FFT, quantization problems (e.g., companding and limit cycles).
Prerequisite: ELEC_ENG 359-0.

ELEC_ENG 372-1 Robot Design Studio (1 Unit)

In this course, teams of students will design and build robots. For instance, teams may build robots inspired by the Summer Olympics: a robot that can perform on the uneven bars, that can skate a half-pipe, or that can do flips on a BMX bike. The ultimate goal is to build a robust, elegant machine capable of performing exciting dynamic feats. Along the way, students will refine skills in mechatronics, electromechanical design, real-time programming, sensor selection and integration, motor/transmission design, and feedback control.
Prerequisite: Consent of Instructor.

ELEC_ENG 372-2 Robot Design Studio (1 Unit)

In this course, teams of students will design and build robots. For instance, teams may build robots inspired by the Summer Olympics: a robot that can perform on the uneven bars, that can skate a half-pipe, or that can do flips on a BMX bike. The ultimate goal is to build a robust, elegant machine capable of performing exciting dynamic feats. Along the way, students will refine skills in mechatronics, electromechanical design, real-time programming, sensor selection and integration, motor/transmission design, and feedback control.
Prerequisite: ELEC_ENG 372-1.

ELEC_ENG 373-0 Deep Reinforcement Learning (1 Unit) Fundamentals of Deep Reinforcement Learning starting from its roots in dynamic programming and optimal control, and ending with some of the most popular applications in practice today; basic Q-Learning algorithm and its extensions; deep Q-Learning. Through exercises and a final course project students will gain significant hands-on experience coding up and testing reinforcement systems on a variety of interesting problems.
Prerequisites: ELEC_ENG 375-0 and ELEC_ENG 335-0.

ELEC_ENG 374-0 Introduction to Digital Control (1 Unit)

Discrete dynamics systems; discrete models of continuous systems feedback and digital controllers; analog-digital conversion; digital control design including PID, lead/lag, deadbeat, and mode-matching controllers.
Prerequisite: ELEC_ENG 360-0.

ELEC_ENG 375-0 Machine Learning: Foundations, Applications, and Algorithms (1 Unit) The course covers the fundamentals of machine learning and numerical optimization, with many application examples.

ELEC_ENG 378-0 Digital Communications (1 Unit)

Sampling and time-division multiplexing, baseband digital signals and systems. Coded pulse modulation, error control coding, digital modulation systems, information measure and source encoding, and introduction to spread spectrum communications.
Prerequisite: ELEC_ENG 302-0 or equivalent.

ELEC_ENG 379-0 Lasers and Coherent Optics (1 Unit)

Optical resonators; fundamental operation of lasers; mode-locking and Q-switching; optical propagation and diffraction; Gaussian beams; thin-lens imaging; optical signal processing.

ELEC_ENG 380-0 Wireless Communications (1 Unit)

Overview of existing and emerging wireless communications systems; interference, blocking, and spectral efficiency; radio propagation and fading models; performance of digital modulation in the presence of fading; diversity techniques; code-division multiple access.
Prerequisite: ELEC_ENG 378-0.

ELEC_ENG 381-0 Electronic Properties of Materials (1 Unit)

Fundamental properties of electrons in materials. Classical and quantum mechanical descriptions of free and bound electrons. Optical, electrical, thermal, and magnetic properties of materials. Microelectronic, optoelectronic, magnetic recording, superconductivity.
Prerequisite: ELEC_ENG 223-0 or consent of instructor.

ELEC_ENG 382-0 Photonic Information Processing (1 Unit)

Introduction to photonic information processing; coherent and incoherent light; electro-optic and acousto-optic modulation; optical signal processing; holography; optical storage.

Prerequisites: ELEC_ENG 222-0 and ELEC_ENG 224-0 or consent of instructor.

ELEC_ENG 383-0 Fiber-Optic Communications (1 Unit)

Semiconductor diode lasers, internal modulation, electro-optic modulation, coherent and incoherent detection, optical fibers and their properties, optical amplifiers, communication systems, optical networks. Prerequisites: ELEC_ENG 223-0, ELEC_ENG 224-0.

ELEC_ENG 384-0 Solid State Electronic Devices (1 Unit)

Energy-band model for semiconductors; carrier statistics and transport; diodes, bipolar and field-effect transistors; integrated circuits, optoelectronic and heterojunction devices. Prerequisite: ELEC_ENG 381-0 or consent of instructor.

ELEC_ENG 385-0 Optoelectronics (1 Unit)

Introduction to solid-state optoelectronic devices; display devices, laser diodes, photodetectors, and light modulators; optical waveguides and fibers; system application of optoelectronic devices. Prerequisite: ELEC_ENG 381-0 or consent of instructor.

ELEC_ENG 387-0 Advanced Digital Systems Design with FPGAs (1 Unit)

This course covers the systematic design of advanced digital systems using field programmable gate arrays (FPGAs). The course presents a top-down design methodology, where students learn how to translate software applications in high-level level languages (such as C/C++) into SystemVerilog models to run on FPGAs. The course focuses on designing real-time high-performance computing applications using industry-standard methodologies, with an emphasis on simulation-based verification and debugging.

ELEC_ENG 388-0 Nanotechnology (1 Unit)

Physics and fabrication of photonic and electronic devices. Physics of semiconductors: crystal structures, reciprocal lattice, elements of quantum mechanics, heterojunctions, quantum wells, and superlattices. Bulk crystal, thin-film, and epitaxial growth technologies. Device processing technologies: diffusion oxidation, ion implantation, annealing, etching, and photolithography.

Prerequisite: ELEC_ENG 223-0 or consent of instructor.

ELEC_ENG 389-0 Superconductivity and Its Applications (1 Unit)

Properties of materials in the superconducting state; charge flow dynamics of type II superconductors; highT_c superconductors; applications for computers and high-frequency devices.

Prerequisite: ELEC_ENG 381-0 or consent of instructor.

ELEC_ENG 390-0 Introduction to Robotics (1 Unit)

Homogeneous vectors and planes; homogeneous transformation, position and orientation transformations, kinematics and inverse kinematic solutions of robot manipulators; Jacobian and inverse Jacobian relation; robot trajectory and task planning; dynamic formulation and computation of robot manipulators; robot programming and control systems.

Prerequisite: COMP_SCI 230-0.

ELEC_ENG 395-0 Special Topics in Electrical Engineering (1 Unit)

Topics suggested by students or faculty and approved by the department.

ELEC_ENG 398-0 Electrical Engineering Design (1 Unit) Design of electrical and electronic devices, circuits, and systems by the application of the engineering sciences, economics, and Institute of Electrical and Electronics Engineers or other national standards. Prerequisite: senior standing.

ELEC_ENG 399-0 Projects (1 Unit) Seminar and projects for advanced undergraduates on subjects of current interest in electrical and computer engineering.