ELECTRICAL ENGINEERING (ELEC)

ELEC 1201 - Fundamentals of Engineering Design Innovation (3 Credits)
This course introduces concepts of engineering design innovation at a variety of scales and disciplines. Participants will experience and explore core technology and design themes including design principles, processes, methods, modes of thinking, and social and cultural aspects or design. Cross-listed with CSCI 1200, CVEN 1200, ENGR 1200, MECH 1200 and IWKS 2100. Max hours: 3 Credits.
Grading Basis: Letter Grade
Typically Offered: Fall, Spring, Summer.

ELEC 1510 - Digital Logic (3 Credits)
The design of combinatorial and sequential switching circuits. Topics include Boolean algebra, Boolean function minimization technique, combinatorial circuit analysis and synthesis, synchronous sequential circuit analysis and synthesis, algorithmic state machine design, asynchronous sequential circuit analysis and synthesis. Max hours: 3 Credits.
Grading Basis: Letter Grade

ELEC 1520 - Programming for Electrical Engineers (3 Credits)
An introductory course in programming using C/C++ and Python. The objective of the course is to examine the design of programs using language concepts, data structures, algorithms, and object-oriented design techniques to solve fundamental engineering problems. Students develop skills to program, construct data structures, and test & debug solutions, while gaining knowledge of the fundamental elements and operation of computer systems. Max Hours: 3 Credits.
Grading Basis: Letter Grade

ELEC 2132 - Circuit Analysis I (3 Credits)
Introduces circuit analysis: basic principles, operational amplifier circuits, first-order and second-order circuits, steady-state sinusoidal analysis with phasor mathematics. Prerequisite: Math 2411 with a C- or higher and Phys 2311 with a C- or higher. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: PHYS 2311 and MATH 2411 with a C- or higher

ELEC 2142 - Circuit Analysis II (3 Credits)
Sequential course after ELEC 2132. Topics include: Solution of circuits using Laplace transforms, frequency domain analysis, additional steady-state solutions, Bode plots, active filters, pulses, impulses, and computer-aided analysis. Prerequisite: Math 2421 with a C- or higher and Phys 2331 with a C- or higher, Elec 2132 with a C- or higher. This course can be taken stand alone without a lab. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 2132, MATH 2421 and PHYS 2331 with a C- or higher.

ELEC 2520 - Embedded Systems (3 Credits)
A second semester computer engineering course covering microcontroller & microprocessor-based embedded system design and interfaces including peripherals, development tools, constraints and interfacing between physical world and device. Prereq: ELEC 1520 with a C- or higher. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 1520 with a C- or higher.

ELEC 2531 - Logic Laboratory (1 Credit)
Experiments in digital logic utilizing both computer simulation and actual analysis using integrated circuits. Initially, combinational logic circuits are studied, including circuits such as binary adders and multipliers, followed by sequential circuits, including counters. Meters and oscilloscopes are introduced. Use of computer-aided design tools facilitating design, simulation, and implementation of digital systems using field-programmable logic devices are an integral part of the entire course. Coreq: ELEC 1510. Max hours: 1 Credit.
Grading Basis: Letter Grade
Coreq: ELEC 1510.

ELEC 2651 - Signal Processing (3 Credits)
Introduction to discrete-time signal processing and frequency domain analysis. Sampling and interpolation, discrete Fourier transform, effects of filtering and modulation of signals. Concepts are explored in the context of multimedia, communications, and data analysis applications. Emphasizes computer-based signal processing using MATLAB. Prereq: ELEC 1520 with a C- or better. Coreq: MATH 3195 or MATH 3191. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 1520 with a C- or better. Coreq: MATH 3195 or MATH 3191.

ELEC 3030 - Electric Circuits and Systems (3 Credits)
This basic electrical engineering course is for non-majors (does not apply to BSEE degree). Students study circuit analysis, transformers, electric motors, and simple electronic circuits (diodes and transistors). Prereq: MATH 2421 and PHYS 2331 with a C- or higher. Restriction: Restricted to majors within the College of Engineering, Design and Computing. Cross-listed with MECH 3030. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: MATH 2421 and PHYS 2331 with a C- or higher Restriction: Restricted to majors within the College of Engineering, Design and Computing

ELEC 3133 - Electromagnetic Fields (3 Credits)
Fundamental physics and applications of electric and magnetic fields are covered. Topics include: vector analysis in multiple coordinate systems, Maxwell's equations in free space and material regions including boundary conditions, static and quasi-static electric and magnetic fields, uniform plane waves for free space and for materials. Prerequisite: MATH 2421 with a C- or higher and PHYS 2331 with a C- or higher, ELEC 2132 with a C- or higher, MATH 3195 with a C-or higher. Restriction: Restricted to students within the College of Engineering, Design and Computing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 2132, MATH 2421, MATH 3195 (or MATH 3191 and MATH 3200), and PHYS 2331 all with a grade of C- or higher. Restriction: Restricted to students within the College of Engineering, Design and Computing

ELEC 3164 - Energy Systems (3 Credits)
Explores various energy resources and modern conversion systems utilized to generate, store, process, and deliver electric power. Topics include electromechanical, electrochemical, and renewable energy systems, as well as switch-mode power processing and power networks. Prereq: ELEC 2142 with a C- or higher, and ENGR 1130 with a C- or higher. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 2142 with a C- or higher, and ENGR 1130 with a C- or higher.

ELEC 3225 - Electronics (4 Credits)
BJT and FET transistor models at high frequencies, multistage amplifiers, frequency response of amplifiers. Feedback, operational amplifiers, oscillators, power amplifiers, and introduction to power electronics. Prereq: ELEC 2142, PHYS 2331 and ENGR 1130. Restriction: Restricted to students within the College of Engineering, Design and Computing. Max hours: 4 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 2142 with a C- or better, PHYS 2331 with a C- or better and ENGR 1130 with a C- or better. Restriction: Restricted to students within the College of Engineering, Design and Computing.

ELEC 3316 - Signals and Systems (3 Credits)
Introduces the fundamentals of signals and systems analysis. Topics include: time domain analysis of continuous and discrete time systems, frequency domain (Laplace and z-transform) analysis, applications to filters and feedback systems, Fourier transform for both continuous and discrete time signals, sampling and signal reconstruction, applications to communication systems and state space representation. Learning experience is enhanced by using MATLAB-based examples and experiments. Prereq: ELEC 2142 with a C- or higher, ELEC 2531 with a C- or higher, ELEC 2651 with a C- or higher, MATH 3195 with a C- or higher or MATH 3191 and MATH 3200 with a C- or higher Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 2142 with a C- or higher, ELEC 2531 with a C- or higher, ELEC 2651 with a C- or higher, MATH 3195 with a C- or higher or MATH 3191 and MATH 3200 with a C- or higher.

ELEC 3520 - Intelligent Systems: IoT & Cyber-Physical Systems (3 Credits)
A computer engineering course covering intelligent systems that include applications with connected Internet-of-Things (IoT) devices and cyber-physical elements. An intelligent system consists of a collection of computing devices communicating with one another and capable of interacting with the physical world. The course explores the system design and software development process to deploy real-time embedded applications in real-world scenarios. Topics include multiple hardware and software systems necessary to perform sensing, actuation, processing, and communication with connected computing devices. Prereq: ELEC 2520 with a C- or better, ELEC 2531 with A C- or better and ELEC 2651 with a C- or better. Max hours: 3 Credits
Grading Basis: Letter Grade
Prereq: ELEC 2520 with a C- or better, ELEC 2531 with A C- or better and ELEC 2651 with a C- or better.

ELEC 3701 - Machine Learning for Engineers (3 Credits)
The course introduces the mathematical formalism and software for machine learning approaches in electrical engineering problems. Selected applications include signal detection, signal classification, remote sensing, imaging, and model optimization. Topics include: linear and logistic regression, support vector machines, clustering, artificial neural networks, hypothesis testing, and Bayesian analysis. Prereq: ELEC 3817 with a C- or better and MATH 3195 with a C- or better or MATH 3191 and MATH 3200 and ELEC 2520 with a C- or better. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3817 with a C- or better AND (MATH 3195 or (MATH 3191 and MATH 3200 with a C- or better and ELEC 2520)).

ELEC 3724 - Energy Systems Laboratory (1 Credit)
Provides hands-on experience on electromechanical, electrochemical, and semiconductor-based energy conversion systems. Sessions include operation of induction motor and generator, energy storage, and renewable energy experiments. Prereq: ELEC 2142 with a C- or better. Prereq or Coreq: ELEC 3164. Max hours: 1 Credit.
Grading Basis: Letter Grade
Prereq: ELEC 2142 with a C- or better. Prereq or Coreq: ELEC 3164.

ELEC 3817 - Engineering Probability and Statistics (3 Credits)
Topics include: definition of probability, conditional probability, independence, combined experiments and Bernoulli trials, random variables, joint distribution and density functions, correlations, sample mean and variance. Also, introduction to random processes, auto and cross correlation functions, spectral density of random signals, responses of a linear system to random inputs. Prereq: MATH 3195 with a C- or better and Math 2421 with a C- or better. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: MATH 3195 with a C- or better and Math 2421 with a C- or better.

ELEC 3900 - Circuit Design and Fabrication (3 Credits)
Course with Hands-on content that involves electrical measurement and diagnosis in the context of electrical circuit design, fabrication, and validation. Standard benchtop tools of oscilloscope, signal generator, digital multi-meter, DC power supply are introduced. Final project involves layout and fabrication of a printed circuit board (PCB). Prereq: ELEC 3225 with a C- or better and ELEC 2142 with a C- or better. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3225 with a C- or better and ELEC 2142 with a C- or better.

ELEC 3939 - Internship (1-3 Credits)
Students gain engineering design experience involving application of specific technical concepts and skills in a supervised industrial environment. (Must have approval from ELEC faculty.) Prereq: ELEC 2142. Repeatable. Max Hours: 9 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 9.
Prereq: ELEC 2142

ELEC 4005 - IC Design (3 Credits)
Explores digital integrated circuit design including MOS processing steps, physical operation, building blocks of digital circuits, advanced nMOS, pMOS and CMOS circuit design, silicon VLSI technology and circuit and chip level. Spice and lay-out Editor are used. The physical relationship between circuit design and actual silicon layout and structure and technology are emphasized. Prereq: ELEC 3225. Cross-listed with ELEC 5005. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3225.

ELEC 4025 - Device Electronics (3 Credits)
A course relating performance and limitations of solid state devices to their structures and technology. For both advanced circuit and device engineers. Semiconductor physics and technology, pn-junction and MOS devices used in modern integrated circuits. Prereq: ELEC 3225 and senior standing. Cross-listed with ELEC 5025. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3225 Restriction: Senior standing

ELEC 4133 - Advanced Electromagnetic Fields (3 Credits)
A course focused on electromagnetic waves. Topics include: electromagnetic power, reflection and transmission of uniform plane waves in layered media, rectangular wave guides, two-conductor transmission lines, Smith Chart representation of wave impedance and reflection. Prereq: ELEC 3133. Cross-listed with ELEC 5033. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3133 Restriction: Restricted to students within the College of Engineering, Design and Computing

ELEC 4134 - Introduction to Microwave Circuit Design (3 Credits)
This course provides the basic principles of microwave circuit design, including transmission line theory, network parameters, signal flow graphs, design of high frequency matching networks, filters, hybrids and couplers using waveguide elements, high frequency amplifier and mixer design. Prereq: ELEC 3133. Cross-listed with ELEC 5134. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3133

ELEC 4136 - Control Systems Analysis (3 Credits)
Introduces students to the fundamentals of analysis and design of feedback systems. Topics include: mathematical models of linear continuous-time systems applied to modeling physical systems in the time and frequency domain, control system characteristics, Routh's stability and transient response analysis, Nyquist stability and polar plots, analysis and design of linear control systems by root locus and frequency response, methods, compensator implementation, finite-precision numerical effects, round-off errors, and computer-based design applications. Prereq: ELEC 3316. Coreq: ELEC 3817. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3316 Coreq: ELEC 3817 Restriction: Restricted to students within the College of Engineering, Design and Computing

ELEC 4154 - Electric and Hybrid Vehicle Powertrains (3 Credits)
Covers the fundamental components and operation of electric and hybrid vehicles' drivetrain. Topics include electric vehicle history, major vehicle components, fundamental vehicle dynamics, electric and hybrid drivetrain configurations, electric motors and drives, energy storage, and power electronics chargers. Restriction: Junior Standing. Cross-listed with ELEC 5154. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to undergraduate students at a junior standing or higher
Typically Offered: Fall.

ELEC 4164 - Electric Machines and Drives (3 Credits)
Covers power electronics drives for rotating electric machinery. Topics include power electronics elements for drives, load characteristics, dynamic modeling of AC machines, fundamental control algorithms, simulation and practical commercial drives. Prereq: ELEC 3164. Cross-listed with ELEC 5164. Repeatable. Max Hours: 9 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 9.
Prereq: ELEC 3164 Restriction: Restricted to students within the College of Engineering, Design and Computing

ELEC 4170 - Electric Machines and Drives Laboratory (1 Credit)
Offers hands-on experience on rotating electric machine drive simulations and commercial systems. Sessions include pulse-width modulation (PWM) inverter, induction, DC, and synchronous machine drives. Matlab/Simulink and a commercial inverter will be utilized. Prereq or Coreq: ELEC 4164/5164 or equivalent. Cross-listed with ELEC 5170. Max hours: 1 Credit.
Grading Basis: Letter Grade
Prereq or Coreq: ELEC 4164 or ELEC 5164
Typically Offered: Fall.

ELEC 4174 - Power Electronic Systems (3 Credits)
Topics to be covered include: power electronics fundamentals and applications in power systems; uncontrolled, semi-controlled and fully controlled power semiconductors; converters design and control. Prereq: ELEC 3164. Cross-listed with ELEC 5174. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3164 Restriction: Restricted to students within the College of Engineering, Design and Computing

ELEC 4184 - Power Systems Analysis (3 Credits)
Topics to be covered include: complex power; per-unit quantities; modeling of generators, transformers and transmission lines; power flow problem; economic dispatch; faults and sequence networks; and an introduction to power system protection and dynamics. Prereq: ELEC 3164. Cross-listed with ELEC 5184. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3164 Restriction: Restricted to students within the College of Engineering, Design and Computing

ELEC 4212 - Fundamentals of Reliability Engineering (3 Credits)
Reliability Engineering is a critical part of systems engineering and sustainability design. There are four objectives of this course: 1) to introduce systems and controls in the design process, 2) to apply reliability fundamentals to civil, computer science, bio-engineering, mechanical, and electrical engineering projects and systems , 3) to employ and explore sustainability design in engineering projects, and 4) to prepare for the American Society of Quality Control (ASQC) test: the Certified Reliability Engineer Certification (CRE). Prereq: ELEC 3817 or Instructor Permission. Cross-listed with ELEC 5212. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3817.
Typically Offered: Summer.

ELEC 4225 - Advanced Electronics (3 Credits)
Switching state models of discrete components and integrated circuits, including logic gates, comparators, and operational amplifiers. Input, output, and transfer characteristics. Non-ideal properties. Analog-digital and digital-analog conversion. MOS-integrated circuits. Prereq: ELEC 3225 and Coreq: ELEC 3900. Restriction: Restricted to students within the College of Engineering, Design and Computing. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3225 and Coreq: ELEC 3900. Restriction: Restricted to students within the College of Engineering, Design and Computing.

ELEC 4247 - Communication Theory (3 Credits)
Introduces the principles of analog and digital communication systems. Series expansion and Fourier Series and transforms. The sampling theorem. Stochastic principles and noise. Linear systems and Fourier analysis. Design of transmitters and receivers: modulation and demodulation schemes. Some information theoretic concepts: source coding, channel coding, channel capacity and performance measures. Prereq: ELEC 3316 and 3817. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Pre-req: ELEC 3316 and 3817

ELEC 4248 - Digital Communication Systems (3 Credits)
Introduces digital communication systems covering elements of information theory; mathematical representation of signals and systems; modulation and demodulation for the additive Gaussian noise channel; performance analysis of various transmission formats; synchronization; coded waveforms; decoding algorithms; and other related topics. Prereq: ELEC 3316, 3817; recommended ELEC 4247. Cross-listed with ELEC 5248. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Pre-req: ELEC 3316 and 3817

ELEC 4249 - Wireless networking (3 Credits)
Fundamentals of wireless communication from a physical-layer perspective. Multipath signal propagation and fading channel models. Design of constellations to exploit time, frequency, and spatial diversity. Reliable communication and single-user capacity. Interference management, multiple-access protocols, and multi-user capacity. Cellular uplink and downlink. Multiple-antenna systems and architectures. Communications with Intelligent Reflecting Surfaces. mmWave and THz communications. Connections to modern standards. Prereq: Elec 3817 and Elec 3316. Cross-listed with ELEC 5249. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3316 and ELEC 3817

ELEC 4250 - Information Inference and Learning Algorithms (3 Credits)
We indulge in a journey from the theory of information to the world of applications. We talk about what information means and provide the means to measure it. We then investigate various methods for extracting what matters from the available data. We bring in topics such as Bayesian data modeling, clustering algorithms, and neural networks to name a few. Prereq: ELEC 3316 and ELEC 3817 with a C- or higher. Cross-listed with ELEC 5250. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3316 and ELEC 3817 with a C- or higher.
Typically Offered: Fall.

ELEC 4276 - Digital Control Systems (3 Credits)
Topics to be covered include: discrete-time systems and the z-transform, characteristics of open-loop and closed-loop discrete-time systems, time-response characteristics and stability analysis, design of digital and hybrid control systems using z-transform, root locus, frequency domain, and state variable compensation techniques, compensator on, implementation, and computer-based design applications. Prereq: ELEC 3316 and ELEC 3817. Cross-listed with ELEC 5276. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3316

ELEC 4309 - Senior Design Project I (3 Credits)
Design methodology and tools, project planning and team building, ethics in engineering and research, career planning and portfolio building. Project designs are completed and presented to the class. Prereq: ELEC 2531. Coreq: ELEC 3133, 3164, 3225, 3316, 3724, 3900, and 3817. Restriction: Restricted to undergraduate majors within the College of Engineering, Design and Computing. ELEC 4309 and ELEC 4319 must be completed in subsequent academic semesters. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 2531. Coreq: ELEC 3133, 3164, 3225, 3316, 3724, 3900, and 3817. Restricted to undergraduate majors within the College of Engineering, Design, and Computing. ELEC 4309 and ELEC 4319 must be completed in subsequent academic semesters.

ELEC 4319 - Senior Design Project II (3 Credits)
Project designs completed in ELEC 4309 are constructed and tested. Oral and written presentations of the completed project performance are required. Prereq: ELEC 4309 with a C- or higher. Coreq: ELEC 3701 and ELEC 3520. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 4309 with a C- or higher. Coreq: ELEC 3701 and ELEC 3520/
Typically Offered: Spring.

ELEC 4333 - Introduction to Computational Electromagnetics (3 Credits)
An intro to computational electromagnetics based on the Finite Difference Time-Domain (FDTD) covering, finite difference methods, the Yee algorithm, numerical error, stability, boundary conditions, source excitations, hands-on programming experience and application of FDTD to real problems. Prereq: ELEC 3133. Cross-listed with ELEC 5333. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3133

ELEC 4373 - Optical Engineering (3 Credits)
This course introduces some of the most important concepts in optical engineering and prepares students a solid foundation to apply them to applications in the industry and academic research. Prereq: ELEC 3133 Electromagnetic Fields. Cross-listed with ELEC 5373. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3133

ELEC 4375 - Engineering Neuroscience (3 Credits)
In this course, mathematical models and data processing strategies will be introduced as well as other cutting-edge research techniques to help students understand how these techniques can be applied to solve modern neuroscience problems. Prereq: ELEC 3316 or graduate standing. Cross-listed with ELEC 5735 and NRSC 7674 (Anschutz Medical Campus course). Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3316 or Graduate Standing

ELEC 4406 - Control Systems Laboratory (1 Credit)
This lab includes system identification, design of velocity control systems, design of PID controllers and control systems using state variable feedback. Prereq or Coreq: ELEC 4136 or 4276. Max hours: 1 Credit.
Grading Basis: Letter Grade
Prereq or Coreq: ELEC 4136 or 4276.

ELEC 4423 - Radio Frequency Laboratory (1 Credit)
Projects involve modern RF analyzers, wave-guide devices, time-domain techniques, characterization of filters/amplifiers, signal propagation and scattering, harmonic mixing, and radio frequency identification. Students will gain experience using MATLAB for data acquisition and processing. Prereq: ELEC 3133 and ELEC 3225. Cross-listed with ELEC 5423. Max hours: 1 Credit.
Grading Basis: Letter Grade
Prereq: ELEC 3133 and ELEC 3225.

ELEC 4435 - Advanced Electronics Laboratory (1 Credit)
Projects related to digital logic, analog and digital switches, A/D and D/A converters, and design of signal filters. Prereq: ELEC 3225. Coreq: ELEC 3900 and ELEC 4225. Max hours: 1 Credit.
Grading Basis: Letter Grade
Prereq: ELEC 3225. Coreq: ELEC 3900 and ELEC 4225.

ELEC 4444 - Power Systems Laboratory (1 Credit)
This lab introduces the student to modern computational tools used in power system analysis. Algorithms to solve the "power flow problem," the "economic dispatch problem," and the "optimal power flow problem" are discussed and implemented in the Matlab-Simulink mathematical analysis software package. Coreq: ELEC 4184. Max hours: 1 Credit.
Grading Basis: Letter Grade
Coreq: ELEC 4184.

ELEC 4467 - Communications Laboratory (1 Credit)
Analysis and design in three main areas: traditional analog communications at low and medium frequencies, digital communications, and microwave communications systems. Extensive use of spectrum analysis from low frequencies up to microwave range. Projects include noise, AM, FN, PM, PLL, sampling, quantizing, encoding, TDM, FSK, QPSK, 16QAM, receivers, and satellite communications systems. Prereq: ELEC 3735; Prereq or Coreq: ELEC 4247 or ELEC 4248. Max Hours: 1 Credit.
Grading Basis: Letter Grade
Prereq: ELEC 3735 and 4247 or 4248

ELEC 4474 - Power Electronics Laboratory (1 Credit)
The power electronics laboratory introduces students to seven fundamental switchmode power conversion topologies, along with voltage and current feedback control, assembled on a reconfigurable power pole circuit board with external power supplies and laboratory. Coreq: ELEC 4174. Cross-listed with ELEC 5474. Max Hours: 1 Credit.
Grading Basis: Letter Grade
Coreq: ELEC 4174 Restriction: Restricted to students within the College of Engineering, Design and Computing

ELEC 4501 - Microprocessor Based Design (3 Credits)
Covers advanced treatment of embedded system design using microprocessors. Analog input circuitry is interfaced to a microprocessor, and a PC board layout is created to develop a complete system design. Software/Operating System is implemented for realtime I/O. Prereq/Coreq: ELEC 3520. Cross-listed with ELEC 5501. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq/Coreq: ELEC 3520.

ELEC 4511 - Hardware-Software Interface (3 Credits)
Computer engineering methods in hardware and software design applied to problems drawn from the mini- and micro-computer systems field. Hardware and software techniques for the design of combined hardware or software are developed. Interface and real-time programming techniques are considered. Graduate level requires additional projects and homework. Prereq: ELEC 3520. Cross-listed with ELEC 5511. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3520.

ELEC 4521 - Microprocessor Laboratory (1 Credit)
Provides support for the projects assigned in ELEC 4501 - a complete embedded system is designed, built and tested. Coreq: ELEC 4501. Max Hours: 1 Credit.
Grading Basis: Letter Grade
Coreq: ELEC 4501

ELEC 4531 - Introduction to Deep learning and PyTorch (3 Credits)
This course provides a foundation on neural networks of deep learning. Students will gain both theoretical and practical understanding of different deep neural networks and will work on a few real-world problems. Prereq: ELEC 3520. Cross-listed with ELEC 5531. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3520.
Typically Offered: Spring, Summer.

ELEC 4541 - Advanced Deep Learning for Computer Vision (3 Credits)
This course introduces the state-of-the-art deep learning research work. Students will gain both theoretical and practical understanding of deep learning in computer vision area. Prereq: ELEC 3520. Cross-listed with ELEC 5541. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3520.
Typically Offered: Spring, Summer.

ELEC 4555 - VLSI Circuit Simulation (3 Credits)
Computer methods for large integrated circuits. Theory and practice of VLSI circuit simulation. Nodal formulations of networks. Computer generation of sensitivities. Modeling active devices. DC solution of nonlinear networks. Prereq: ELEC 3225. Cross-listed with ELEC 5555. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3225.

ELEC 4561 - Hardware-Software Lab (1 Credit)
Projects related to the software interface of a processor to external devices. Topics include A/D converters, serial and parallel interfaces. Prereq: ELEC 3520 and Coreq: ELEC 4511. Max hours: 1 Credit.
Grading Basis: Letter Grade
Prereq: ELEC 3520 and Coreq: ELEC 4511.

ELEC 4637 - Digital Signal Processing (3 Credits)
Discrete-time signals and systems in the time and frequency domain. Digital filter structures, design of FIR filters by windowing, optimum approximations of FIR filters. Design of digital IIR filters from continuous time domain. Computer-aided design of digital filters. The discrete Fourier transform and DSP algorithm implementation. Analysis of finite word length effects. Application of digital signal processing. Prereq: ELEC 3316 and 3817. Cross-listed with ELEC 5637. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3316 and ELEC 3817

ELEC 4644 - Introduction to Medical Imaging (3 Credits)
This course will introduce students to the basic physics, technologies, and clinical methodologies underlying Ultrasound, MRI,CT, PET and SPECT imaging systems. The course will include lectures, and visits to campus hospital and research imaging systems as well as hands on ultrasound labs. Prereq: ELEC 2651 or graduate standing. Cross-listed with ELEC 5644. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 2651 or graduate standing.

ELEC 4678 - Quantum Computing (3 Credits)
The course teaches students the principles, the algorithms and the programming methods of quantum computing, and also discusses the associated physics and mathematics background required. Other related topics such as quantum communication and quantum entanglement will also be discussed. Prereq: ELEC 3817 or CSCI 3560/4650/4110 with a C- or better. Cross-listed with ELEC 5678, PHYS 4678, and PHYS 5678. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3817 or CSCI 3560/4650/4110 with a C- or better.
Typically Offered: Fall.

ELEC 4679 - Quantum Computing Algorithms (3 Credits)
The course discusses several seminal quantum algorithms, including the quantum Fourier transforms, Grover's and Shor's algorithms, followed by explaining several advanced quantum computing algorithms, including quantum error correction, sparse linear systems, and variational eigensolver. Google Cirq quantum programming library will be used for actual quantum programming implementations of the algorithms discussed. Prereq: ELEC 4678 or ELEC 3817 or CSCI 3560/4650/4110 with a C- or better. Cross-listed with ELEC 5679, PHYS 4679, and PHYS 5679. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 4678 or ELEC 3817 or CSCI 3560/4650/4110 with a C- or better.
Typically Offered: Fall.

ELEC 4680 - Quantum Computing Technology (3 Credits)
Students will explore some of the concepts and experimental practices for realizing quantum computers. They will engage in laboratory practice of relevant skills including high-performance analog electronics; optics based quantum encryption and eraser implementations; RF electronics; and vacuum and cryogenic techniques. Prereq: ELEC 3900 with a C- or higher or Permission of Instructor. Cross-listed with ELEC 5680, PHYS 4680, and PHYS 5680. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3900 with a C- or higher.
Typically Offered: Fall.

ELEC 4681 - Quantum Technology Systems (3 Credits)
Students will explore a systems approach toward experimental practices for realizing quantum information science and engineering (QISE), with a focus on vacuum and cryogenic techniques and integration of electronics subsystems into a "dry" cryostat. They will engage in laboratory practice of relevant skills including creation and measurement of high vacuum, methods for reaching ultra-low temperatures, concerns in the design and construction of cryogenic apparatuses, and operation of a "dry" cryogenic system at 4 K, including measurements on superconducting quantum interference devices. Prereq: PHYS 4680 OR PHYS 5680 OR ELEC 4680 OR ELEC 5680 with a C- or higher or Permission of Instructor. Cross-listed with PHYS 4681, PHYS 5681 and ELEC 5681. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: PHYS 4680 OR PHYS 5680 OR ELEC 4680 OR ELEC 5680 with a C- or higher.

ELEC 4723 - High Performance Computer Architecture (3 Credits)
High Performance Computer Architecture covers the design of advanced computing systems. In particular, the course includes the design of modern microprocessors, characteristics of the memory hierarchy, and issues involved in multithreading and multicore architectures. Prereq: ELEC 3520. Cross-listed with ELEC 5723. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: ELEC 3520.

ELEC 4727 - Machine Vision Systems (3 Credits)
This course provides an introduction to machine vision systems regarding concepts, algorithms, and applications, especially revealing how the latest vision systems can mimic and even outperform humans in specific tasks. Through practical assignments and projects, students will learn to develop vision systems that can see, interpret, and act on visual data. Key topics include image/video formation and transformation, feature extraction, object recognition, and evaluating vision system performance. By the end of the course, students will have a solid background in machine vision algorithms and be able to advance their knowledge in solving real-world problems. Prereq: Requires prerequisite course of ELEC 3520 and ELEC 3817 (all minimum grade D-). Cross-listed with ELEC 5727. Term offered: Fall. Max hours: 3 Credits.
Grading Basis: Letter Grade
Requires prerequisite course of ELEC 3520 and ELEC 3817 (all minimum grade D-).
Typically Offered: Fall.

ELEC 4755 - Grid Integration of Renewable Energy (3 Credits)
This course focuses on the modeling, analysis and control of grid-connected wind and photovoltaic energy systems. Prereq: ELEC 3164. Cross-listed with ELEC 5755. Repeatable. Max Hours: 9 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 9.
Prereq: ELEC 3164 Restriction: Restricted to students within the College of Engineering, Design and Computing
Typically Offered: Spring.

ELEC 4800 - Special Topics (1-3 Credits)
Repeatable. Max hours: 9 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 9.

ELEC 4802 - Special Topics (3 Credits)
Prereq: ELEC 3701 with a C- or higher. Restriction: Restricted to undergraduate ELEC students. Cross-listed with ELEC 5802. Repeatable. Max hours: 9 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 9.
Prereq: ELEC 3701 with a C- or higher. Restriction: Restricted to undergraduate ELEC students.
Typically Offered: Fall.

ELEC 4810 - Special Topics (1-3 Credits)
Cross-listed with ELEC 5810. Repeatable. Max hours: 9 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 9.

ELEC 4840 - Independent Study: ELEC (1-3 Credits)
An opportunity for independent creative work. Prereq: Permission of instructor. Repeatable. Max Hours: 9 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 9.
Restrictions: Restricted to majors within the College of Engineering, Design and Computing.