

# ELECTRICAL AND COMPUTER ENGINEERING (ECEN)

## Courses

### ECEN 1030 (1-4) Special Topics

Special topics class.

### ECEN 1100 (1) Exploring ECE

Introduces students to areas of emphasis with the ECE department through seminars presented by faculty and outside speakers. Emphasizes career opportunities, professional ethics and practices, history of the profession, and resources for academic success. Several sessions promote team building and problem solving, and provide opportunities for first year students to meet their classmates.

**Requisites:** Restricted to College of Engineering (ENGRU) undergraduates only.

**Additional Information:** Departmental Category: General

### ECEN 1310 (4) C Programming for ECE

Introduces fundamental programming concepts with engineering applications using C at a lower level of abstraction and MATLAB at a higher, application-focused level. Teaches the use of pointers, control flow, and data types. Example engineering applications include signal processing and the numerical computations. Includes a weekly computer lab session.

**Equivalent - Duplicate Degree Credit Not Granted:** CSCI 1300 or CSPB 1300 or CSCI 1310 or CSCI 1320

**Requisites:** Restricted to College of Engineering (ENGRU) undergraduates only.

**Recommended:** Prerequisite APPM 1350.

**Additional Information:** Departmental Category: General

### ECEN 1400 (3) Introduction to Digital and Analog Electronics

Introduces fundamental concepts in electrical and computer engineering such as Ohm's Law, capacitors, LEDs and 7-segment displays, transformers and rectifiers, digital logic, Fourier decomposition, frequency analysis. Lab work exposes students to commonly used instrumentation. Includes a final project. Skills in wiring, soldering and wire-wrapping are developed.

**Requisites:** Restricted to students with 0-56 (Freshmen or Sophomore) College of Engineering majors only.

**Additional Information:** Departmental Category: General

### ECEN 1500 (3) Sustainable Energy

Explores how energy is generated and used in today's society. Through collaborative discussion and hands-on data collection, students will analyze the engineering challenges, fundamental limits, and potential solutions to meeting our energy needs sustainably. Students will learn to analyze numerical data, estimate orders of magnitude, and apply mathematical methods in their own lives and in the ongoing energy debate. Basic algebra required.

**Requisites:** College of Engineering majors are excluded from this course.

**Additional Information:** Arts Sci Core Curr: Quant Reason Mathmat Skills  
Arts Sci Gen Ed: Quantitative Reasoning Math  
Departmental Category: General

### ECEN 1840 (1-6) Independent Study

Provides an opportunity for freshmen to do independent, creative work. Department consent required.

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: General

### ECEN 2010 (1-5) Special Topics

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: General

### ECEN 2020 (1-5) Special Topics

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: General

### ECEN 2050 (1-5) Special Topics

**Additional Information:** Departmental Category: General

### ECEN 2060 (1-5) Special Topics

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: General

### ECEN 2250 (3) Introduction to Circuits and Electronics

Introduces linear circuit analysis and design, including OP-Amps. Presents DC networks, including node and mesh analysis with controlled sources. Analysis of RL and RC circuits for both transient and sinusoidal steady-state responses using phasors.

**Requisites:** Requires prerequisite course of APPM 1360 or MATH 2300 and PHYS 1120 (all minimum grade C-), and corequisite course of APPM 2360. Restricted to College of Engineering majors only.

**Recommended:** Prerequisite ECEN 1310 or CSCI 1300.

**Additional Information:** Departmental Category: General

### ECEN 2260 (3) Circuits as Systems

Continues basic circuit analysis of ECEN 2250: Laplace transform techniques, transfer functions, frequency response, Bode diagrams, resonant circuits, Fourier series expansions, and convolution.

**Requisites:** Requires prerequisite course of ECEN 2250 and APPM 2360 (minimum grade C-). Restricted to College of Engineering students only.

**Recommended:** Corequisite ECEN 2270.

**Additional Information:** Departmental Category: General

### ECEN 2270 (3) Electronics Design Lab

Provides an introduction to analysis, modeling, design, and testing of analog electronic circuits in a practical laboratory setting. The laboratory is centered around a robot platform and includes design, SPICE simulations, prototyping and testing of circuits necessary to drive and remotely control the robot.

**Requisites:** Requires prerequisite course of ECEN 2260 or corequisite course of ECEN 2260. Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: General

### ECEN 2310 (1) Programming with Mathematical Software

Applies mathematical software to the solution of engineering applications, using numerical and symbolic techniques. Typical applications include the manipulation of acoustic signals and the study of the dynamics of simple continuous and discrete systems.

**Requisites:** Requires prerequisites ECEN 1310 or CSCI 1300 or CSCI 1320 (all minimum grade C-). Restricted to College of Engineering students.

**Grading Basis:** Letter Grade

### ECEN 2350 (3) Digital Logic

Covers the design and applications of digital logic circuits, including both combinational and sequential logic circuits. Introduces hardware descriptive language, simulating and synthesis software, and programming of field programmable arrays (FPGAs).

**Requisites:** Requires prerequisite course of ECEN 1310, CSCI 1300, or CSCI 1320 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: General

**ECEN 2410 (3) Renewable Sources and Efficient Electrical Energy Systems**

Introduces electrical power generation and renewable energy, including solar, wind, micro, hydro, coal, nuclear and natural gas and some of the issues in integrating renewable energy sources in the grid.

**Requisites:** Requires prerequisite course of PHYS 1120 (minimum grade C-). Requires corequisite course of ECEN 2250. Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: General

**ECEN 2420 (3) Electronics for Wireless Systems**

Explores fundamental principles behind the operation of a radio, including a practical introduction to circuit elements. Covers the components and operation of a radio (transmitter and receiver) with simple signals. Students learn lab exercises the operation principles behind components of a complete practical radio system.

**Requisites:** Requires prerequisite course of PHYS 1120 and APPM 1360 or MATH 2300 (all minimum grade C-). Requires corequisite course of ECEN 2250. Restricted to Electrical and Computer Engineering (ECEN) or Electrical Engineering (EEEN) majors only.

**Additional Information:** Departmental Category: General

**ECEN 2440 (3) Application of Embedded Systems**

Introduces embedded systems and key computer architecture concepts through a variety of projects involving programming a microcontroller in C. Provides students hands-on projects that combine the knowledge gained in their digital and analog coursework in order to engineer hardware, firmware and application software design solutions. Includes a weekly lecture and two weekly laboratory sessions.

**Requisites:** Requires a prerequisite course of ECEN 1310, CSCI 1300 or CSCI 1320 (minimum grade C-). Requires corequisite course of ECEN 2250.

**Additional Information:** Departmental Category: General

**ECEN 2703 (3) Discrete Mathematics for Computer Engineers**

Emphasizes elements of discrete mathematics appropriate for computer engineering. Topics: logic, proof techniques, algorithms, complexity, relations, and graph theory.

**Requisites:** Requires prerequisite courses of ECEN 1310 or CSCI 1300 or CSCI 1320 and APPM 1360 or MATH 2300 (all minimum grade C-). Restricted to College of Engineering students only.

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 2830 (1-5) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: General

**ECEN 2840 (1-6) Independent Study**

Offers an opportunity for sophomores to do independent, creative work. Department consent required.

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: General

**ECEN 3002 (3-5) Special Topics**

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 3003 (3-5) Special Topics**

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 3004 (3-5) Special Topics**

**Additional Information:** Departmental Category: Electromagnetics and Remote Sensing

**ECEN 3010 (3) Circuits and Electronics for Mechanical Engineers**

Covers analysis of electrical circuits by use of Ohm's law, network reduction, node and loop analysis, Thevenin's and Norton's theorems, DC and AC signals, transient response of simple circuits, transfer functions, basic diode and transistor circuits, and operational amplifiers. Includes introductory digital electronics and microprocessors/microcontrollers.

**Equivalent - Duplicate Degree Credit Not Granted:** MCEN 3017

**Requisites:** Requires prereq course of PHYS 1120 (min grade C). Requires a prereq or coreq course of APPM 2360. Restricted to students with 57-180 credits (Jr or Sr) Mechanical Engr (MCEN) or Engineering Plus (GEEN) majors only.

**Additional Information:** Departmental Category: General

**ECEN 3030 (3) Electrical/Electronic Circuits Non-Major**

For students not majoring in electrical engineering. Covers analysis of electric circuits by use of Ohm's law; network reduction; superposition; node analysis; Thevenin's and Norton's theorems; sinusoidal signals; phasors; power in AC circuits; transient response, operation of simple circuits; rectifiers; transformers; 3-phase circuits; motors and generators.

**Requisites:** Requires prereq course of APPM 2360 (min grade C-). Electrical Computer Engineering (ECEN), Electrical Engineering (EEEN), Electrical Computer Engineering and Electrical Engineering Concurrent Degree (C-ECEN/EEEN) mjrs are excluded from this course

**Additional Information:** Departmental Category: General

**ECEN 3070 (3) Edges of Science**

Examines the evidence for paranormal phenomena, reasons for skepticism, and physical models that could account for the data. Reviews controversial scientific theories that overcame barriers to acceptance, and how worldviews shift. Considers the scientific method and ways uncontrolled factors might influence experiments. Develops skills in statistical analysis of data. Includes group projects testing for anomalous and parapsychological effects. Not accepted as a technical elective for engineering majors.

**Additional Information:** Departmental Category: General

**ECEN 3170 (3) Electromagnetic Energy Conversion 1**

Real and reactive power in single phase circuits, power triangle, balanced three-phase circuits, wye and delta connections, introduction to electromagnetic machines, transformers (single and three-phase) and their equivalent circuits, AC-machinery fundamentals, synchronous generator from a magnetic field point of view, synchronous motors and condensers, three-phase induction motors, DC machinery fundamentals, DC motors, single phase motors. Matlab/Simulink will be used.

**Requisites:** Requires prerequisite courses of ECEN 2260 and PHYS 1120 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Power

**ECEN 3250 (3) Microelectronics**

Develops a basic understanding of active semiconductor devices. Focuses on building an understanding of BJT and CMOS devices in both digital and analog applications.

**Requisites:** Requires prerequisite course of ECEN 2260 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: General

**ECEN 3300 (3) Linear Systems**

Characterization of linear time-invariant systems in time and frequency domains. Continuous time systems are analyzed using differential equations and Laplace and Fourier transforms. Discrete time systems are analyzed using difference equations, Z-transforms and discrete time Fourier transforms. Sampling and reconstruction of signals using the sampling theorem. Applications of linear systems include communications, signal processing, and control systems.

**Requisites:** Requires prerequisite course of ECEN 2260 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: General

**ECEN 3303 (3) Introduction to Robotics**

Introduces students to fundamental concepts in autonomous robotics: mechanisms, locomotion, kinematics, control, perception and planning. Consists of lectures and lab sessions that are geared toward developing a complete navigation stack on a miniature mobile robotic platform.

**Equivalent - Duplicate Degree Credit Not Granted:** CSCI 3302

**Requisites:** Requires prerequisite courses of (CSCI 2270 or CSCI 2275) and (APPM 3170 or CSCI 2824 or ECEN 2703 or MATH 2001) and (APPM 2360 or APPM 3310 or CSCI 2820 or MATH 2130 or MATH 2135) (all minimum grade C-).

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 3320 (3) Semiconductor Devices**

Highlights the fundamentals of semiconductor materials and devices. Topics include the electrical and optical properties of semiconductors, the theory of Pn junctions, bipolar and field-effect transistors, and optoelectronic devices.

**Requisites:** Requires prerequisite course of ECEN 3250 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: General

**ECEN 3350 (3) Programming Digital Systems**

Explores how computers and programmable hardware in general are used to implement digital systems by looking at the capabilities of central processing units, the use and control of various input/output (I/O) devices, memory organization, and concurrency management. Topics include computer architecture, instruction sets, I/O device programming, interrupts, data transfer mechanisms, semaphores, and memory management.

**Requisites:** Requires prerequisite course of ECEN 2350 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 3360 (3) Digital Design Laboratory**

Introduces digital system design, including system software and hardware building blocks, and system software-hardware integration. Emphasizes hands-on system development and debugging. Uses mainstream electronic system design platforms, including FPGAs, embedded and mobile computing platforms, and Assembly/C/Java/Verilog programming languages.

**Requisites:** Requires prerequisite course ECEN 3350 (minimum grade C-) or corequisite of ECEN 3350. Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 3400 (3) Electromagnetic Fields and Waves**

Electromagnetic fields are covered at an introductory level, starting with electrostatics and continuing with DC current, magnetostatics, time-varying magnetic fields, waves on transmission lines, Maxwell's equations and the basics of plane waves. The use of fields in inductors, capacitors, resistors, transformers, and energy and power concepts are studied.

**Requisites:** Requires prerequisites (APPM 2350 or MATH 2400) and APPM 2360 and PHYS 1120 and ECEN 2250 (all minimum grade C-).

Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: General

**ECEN 3410 (3) Electromagnetic Waves and Transmission**

Covers reflected and transmitted plane waves in layered media, Poynting's theorem of electromagnetic power, two-conductor transmission line theory and practice, Smith chart usage and impedance matching, waveguides, and elements of antenna theory.

**Requisites:** Requires prerequisite course ECEN 3400 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Electromagnetics and Remote Sensing

**ECEN 3810 (3) Introduction to Probability Theory**

Covers the fundamentals of probability theory, and treats the random variables and random processes of greatest importance in electrical engineering. Provides a foundation for study of communication theory, control theory, reliability theory, and optics.

**Equivalent - Duplicate Degree Credit Not Granted:** MATH 4510 or APPM 3570

**Requisites:** Requires prerequisite course of APPM 2350 or MATH 2400 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: General

**ECEN 3840 (1-6) Independent Study**

Offers an opportunity for juniors to do independent, creative work. Department consent required.

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: General

**ECEN 3841 (1-6) Independent Study**

Offers an opportunity for juniors to do independent, creative work.

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: General

**ECEN 4000 (1-3) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: General

**ECEN 4001 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Bioengineering

**ECEN 4002 (1-4) Special Topics**

Credit and subject matter to be arranged. Department enforced prerequisite: varies

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 4003 (1-4) Special Topics**

Credit and subject matter to be arranged. Department enforced prerequisite: varies

**Repeatable:** Repeatable for up to 12.00 total credit hours. Allows multiple enrollment in term.

**ECEN 4004 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**ECEN 4005 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**ECEN 4006 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Repeatable:** Repeatable for up to 9.00 total credit hours.

**Additional Information:** Departmental Category: Optics

**ECEN 4007 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**ECEN 4009 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: VLSI CAD Methods

**ECEN 4011 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 5011

**Repeatable:** Repeatable for up to 9.00 total credit hours.

**Additional Information:** Departmental Category: Bioengineering

**ECEN 4012 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 4013 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 4016 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Additional Information:** Departmental Category: Optics

**ECEN 4017 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Additional Information:** Departmental Category: Power

**ECEN 4018 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Additional Information:** Departmental Category: Dynamical Systems and Control

**ECEN 4021 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Repeatable:** Repeatable for up to 9.00 total credit hours.

**Requisites:** Restricted to students with 87-180 credits (Senior, Fifth Year Senior) College of Engineering majors only.

**Additional Information:** Departmental Category: Bioengineering

**ECEN 4024 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 5024

**Additional Information:** Departmental Category: Electromagnetics and Remote Sensing

**ECEN 4028 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Additional Information:** Departmental Category: Dynamical Systems and Control

**ECEN 4031 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**ECEN 4033 (3) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**ECEN 4043 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**ECEN 4053 (1-4) Special Topics**

Special topics course.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 5053

**Repeatable:** Repeatable for up to 4.00 total credit hours.

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 4133 (3) Fundamentals of Computer Security**

Practice thinking like an attacker by exploring several modern computer security attacks and defenses through hands-on programming projects.

Topics include applied cryptography (encryption, authentication), web security (XSS, CSRF, SQL Injection), network security (TLS, MITM attacks), application security (shell injection, buffer overflows), and other current events and trends (government surveillance, botnets, cryptocurrencies).

**Grading Basis:** Letter Grade

**ECEN 4138 (3) Control Systems Analysis**

Analysis and design of continuous time control systems using classical and state space methods. Laplace transforms, transfer functions and block diagrams. Stability, dynamic response, and steady-state analysis. Analysis and design of control systems using root locus and frequency response methods. Computer aided design and analysis.

Department enforced prerequisite: background in Laplace transforms, linear algebra, and ordinary differential equations.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 5138

**Requisites:** Requires prerequisite course of ECEN 3300 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Dynamical Systems and Control

**ECEN 4167 (3) Electromagnetic Energy Conversion 2**

Introduction to electric machine drives, basic electric machine mechanics, structure and modeling of electric machines (DC, Synchronous, Linear, Induction), reference frame theory using d-q modeling based on the complex space vector and on matrix transformation, transient and steady state analysis of three-phase machine, design of speed regulators, vector control. Matlab/Simulink will be used.

**Requisites:** Requires prerequisite course of ECEN 3170 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Power



**ECEN 4224 (3) High Speed Digital Design**

Covers fundamentals of high-speed properties of logic gates, measurement techniques, transmission lines, ground planes and layer stacking, terminations, vias, power systems, connectors, ribbon cables, clock distribution and clock oscillators.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 5224

**Requisites:** Requires prerequisite course of ECEN 3400 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Electromagnetics and Remote Sensing

**ECEN 4242 (3) Communication Theory**

Covers modern digital and analog communication systems. Analysis and design of communication signals, transmitters, channels, and receivers. Amplitude and angle modulation and demodulation are treated as well as theory and application of digital data transmission. Emphasis is also placed on the analysis and mitigation of the effects of noise through signal design at the transmitter and signal processing at the receiver.

**Requisites:** Requires prerequisite course of ECEN 3300 and ECEN 3810 or APPM 3570 or MATH 4510 (all minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 4313 (3) Concurrent Programming**

Introduces the theory and practice of multicore programming. The first part of the course presents foundations of concurrent programming: mutual exclusion, wait-free and lock-free synchronization, spin locks, monitors, memory consistency models. The second part presents a sequence of concurrent data structures and techniques used in their implementations (coarse-grained, fine-grained, optimistic and lock-free synchronization).

**Requisites:** Requires a prerequisite course of ECEN 1310 or CSCI 1300 or CSCI 1320 (all minimum grade C-).

**Grading Basis:** Letter Grade

**ECEN 4322 (3) Data and Network Science**

The course covers the theory and design of algorithms that are used to model, analyze, and extract information from large scale datasets and networks. The course includes a project.

**Requisites:** Requires prerequisite courses of APPM 2350 or MATH 2400 and APPM 2360 or MATH 3430 and CSCI 1200 or CSCI 1300 or CSCI 1320 or ECEN 1310 or INFO 1201 or ATLS 1300 or CHEN 1310 and ECEN 2703 or CSCI 2824 or APPM 3170 or MATH 2001 (all minimum grade C-).

**ECEN 4341 (3) Bioelectromagnetics**

Effects of electric and magnetic fields on biological systems are described with applications to therapy and safety. The complexity of biological systems is described to provide a better understanding of the distribution of fields inside the body. Risk analysis is also introduced.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 5341

**Requisites:** Requires prerequisite courses of ECEN 3400 and ECEN 3810 or APPM 3570 or MATH 4510 (all minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Bioengineering

**ECEN 4423 (3) Chaotic Dynamics**

Explores chaotic dynamics theoretically and through computer simulations. Covers the standard computational and analytical tools used in nonlinear dynamics and concludes with an overview of leading-edge chaos research. Topics include time and phase-space dynamics, surfaces of section, bifurcation diagrams, fractal dimension and Lyapunov exponents.

**Equivalent - Duplicate Degree Credit Not Granted:** CSCI 5446 and CSCI 4446 and ECEN 5423

**Requisites:** Requires prerequisite courses of APPM 1360 or MATH 2300 and ECEN 1310 or CSCI 1300 and PHYS 1110 (all minimum grade C-). Restricted to College of Engineering majors only.

**Recommended:** Prerequisites PHYS 1120 and CSCI 3656 and MATH 2130.

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 4517 (3) Power Electronics and Photovoltaic Power Systems Laboratory**

Focuses on analysis, modeling, design and testing of electrical energy processing systems in a practical laboratory setting. Studies power electronics converters for efficient utilization of available energy sources, including solar panels and utility. Experimental projects involve design, fabrication and testing of a solar power system.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 5517

**Requisites:** Requires prerequisite course of ECEN 4797 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Power

**ECEN 4532 (3) Digital Signal Processing Laboratory**

Develops experience in code development, debugging and testing of real-time digital signal processing algorithms using dedicated hardware. Applications include filtering, signal synthesis, audio special effects and frequency domain techniques based on the Fast Fourier Transform.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 5532

**Requisites:** Requires prerequisite course of ECEN 4632 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 4553 (3) Compiler Construction**

Introduces the principles and techniques for compiling high-level programming languages to assembly code. Topics include parsing, instruction selection, register allocation, and compiling high-level features such as polymorphism, first-class functions, and objects. Students build a complete compiler for a simple language.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 5523 and CSCI 4555 and CSCI 5525

**Requisites:** Requires prerequisite courses of ECEN 2703 and ECEN 3350 (all minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 4555 (3) Principles of Energy Systems and Devices**

Develops principles underlying electronic, optical and thermal devices, materials and nanostructures for renewable energy. Provides a foundation in statistical thermodynamics and uses it to analyze the operation and efficiency limits of devices for photovoltaics, energy storage (batteries & ultra-capacitors), chemical conversion (fuel cells and engines), solid state lighting, heat pumps, cooling and potentially harvesting zero-point energy from the vacuum.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 5555

**Requisites:** Requires prerequisite courses of ECEN 3810 or APPM 3570 or MATH 4510 and PHYS 2130 or PHYS 2170 (all minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Nanostructures and Devices

**ECEN 4583 (3) Software System Development**

Lectures deal with techniques for product requirements definition, project planning, coding, verification, validation, performance evaluation, and maintenance of medium-scale (2-3000 line) systems. Primary emphasis is on practical application of these techniques to a specified software project. Students work in teams to produce appropriate documents for each phase and are responsible for project completion according to specification and schedule. Course project is written in C on a Unix look-alike system; prior knowledge of C or Unix is not required.

**Requisites:** Requires prerequisite course of CSCI 2270 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 4593 (3) Computer Organization**

Studies computer design at the gate level. Discusses instruction set architecture design, arithmetic and logic unit design, control logic, memory design and caches, simple pipelining, I/O and peripheral devices. Briefly covers aspects of modern computer architecture, such as multicore processors and cache coherence for these.

**Equivalent - Duplicate Degree Credit Not Granted:** CSCI 4593

**Requisites:** Requires prerequisite course of ECEN 3350 or CSCI 2400 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 4606 (3) Undergraduate Optics Laboratory**

Introduces fundamental concepts, techniques, and technology of modern optical and photonic systems. Individual labs cover particular fields of optical technology, including light sources such as lasers and LEDs, interferometers, fiber-optic communications, photodetection, spectrometers, and holography. Practical skills such as how to align an optical system will also be emphasized.

**Requisites:** Requires prerequisite course of ECEN 3400 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Optics

**ECEN 4610 (3) Capstone Laboratory Part 1**

Hands-on laboratory experience utilizing teams in the systematic proposal, design, integration, and testing of an electronic/computer based system. Results will be the prototype of a stand-alone analog/digital system. Must have completed all required Advanced Analog Core courses for major, except one course may be taken concurrently by petition. Must take ECEN 4620 to complete the sequence. Minimum required grade for this course and ECEN 4620 is C-.

**Requisites:** Requires prerequisites of ECEN 2270 ECEN 3360 (ECEN 3250 3300) or (ECEN 3250 3400) or (ECEN 3300 3400) (all min grade C-). Restricted to ECEN or EEEN or C-EEEN or C-ECENEEN or C-EEENP or C-ECENEENP or GEEN-BSEPL majors only.

**Additional Information:** Departmental Category: General

**ECEN 4616 (3) Optoelectronic System Design**

Examines optical components and electro-optic devices with the goal of integrating into well design optoelectronic systems. Sample systems include optical storage, zoom lenses and telescopes.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 5616

**Requisites:** Requires prerequisite course of ECEN 3400 (minimum grade C-).

**Additional Information:** Departmental Category: Optics

**ECEN 4620 (3) Capstone Lab, Part 2**

Hands-on laboratory experience for teams in the systematic proposal, design, build integration, test and documentation of an electronic/computer based system. Results will be a reliably operating, stand-alone analog/digital system, with publication quality technical documentation. Department enforced prerequisite: advanced analog core courses.

**Requisites:** Requires prerequisite course of ECEN 4610 (minimum grade C-). Restricted to Electrical and Computer Engineering (ECEN) or Electrical Engineering (EEEN) or ECEE concurrent (C-EEEN or C-ECENEEN) majors only.

**Additional Information:** Departmental Category: General

**ECEN 4632 (3) Introduction to Digital Filtering**

Covers both the analysis and design of FIR and IIR digital filters. Discusses implementations in both software and hardware. Emphasizes use of the FFT as an analysis tool. Includes examples in speech processing, noise canceling, and communications.

**Requisites:** Requires prerequisite course of ECEN 3300 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 4634 (3) Microwave and RF Laboratory**

Introduce RF and microwave measurement methods. A laboratory course whose experiments build on material learned in ECEN 3410: electromagnetic waves, transmission lines, waveguides, time-domain reflection, frequency-domain measurement, microwave networks, impedance matching, antenna pattern measurement, radar and simple nonlinear concepts such as harmonics, square-law detection, mixing and transmitter/receiver applications.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 5634

**Requisites:** Requires prerequisite course of ECEN 3410 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Electromagnetics and Remote Sensing

**ECEN 4638 (3) Control Systems Laboratory**

Provides experience in control system design and analysis, using both real hardware and computer simulation. Covers the entire control system design cycle: modeling the system, synthesizing a controller, conducting simulations, analyzing the design to suggest modifications and improvements, and implementing the design for actual testing.

**Requisites:** Requires prerequisite course of ECEN 4138 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Dynamical Systems and Control

**ECEN 4652 (3) Communication Laboratory**

Analysis and design of realistic communication signals in a modern digital signal processing environment. Covers both analog and digital communication signals with and without noise and distortion. Pulse amplitude modulation is used initially at baseband and then combined with amplitude and phase/frequency modulation to produce the kind of bandpass signals that are used in cell phones and wireless data networks.

**Requisites:** Requires prerequisite course of ECEN 4242 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 4753 (3) Computer Performance Modeling**

Presents a broad range of system measurement and modeling techniques, emphasizing applications to computer systems. Covers topics including system measurement, workload characterization and analysis of data; design of experiments; queuing theory and queuing network models; and simulation.

**Equivalent - Duplicate Degree Credit Not Granted:** CSCI 5753 and CSCI 4753 and ECEN 5753

**Requisites:** Requires prerequisite course of CSCI 3753 (minimum grade C-). Restricted to College of Engineering majors only.

**Recommended:** Prerequisite a course in statistics.

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 4797 (3) Introduction to Power Electronics**

An introduction to switched-mode converters. Includes steady-state converter modeling and analysis, switch realization, discontinuous conduction mode and transformer-isolated converters. Ac modeling of converters using averaged methods, small-signal transfer functions, feedback loop design and transformer design.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 5797

**Requisites:** Requires prerequisite course of ECEN 3250 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Power

**ECEN 4827 (3) Analog IC Design**

Covers the fundamentals of transistor-level analog integrated circuit design. Starting with motivations from application circuits, the course develops principles of dc biasing, device models, amplifier stages, frequency response analysis and feedback and compensation techniques for multi-stage operational amplifiers.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 5827

**Requisites:** Requires prerequisite course of ECEN 3250 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Power

**ECEN 4840 (1-6) Independent Study**

Offers an opportunity for seniors to do independent, creative work. Department consent required.

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: General

**ECEN 4841 (1-6) Independent Study**

Offers an opportunity for seniors to do independent, creative work.

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**ECEN 5000 (3) Graduate Professional Seminar**

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: General

**ECEN 5005 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Nanostructures and Devices

**ECEN 5008 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Dynamical Systems and Control

**ECEN 5009 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: VLSI CAD Methods

**ECEN 5011 (1-4) Special Topics**

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4011

**Repeatable:** Repeatable for up to 9.00 total credit hours.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Bioengineering

**ECEN 5012 (3) Special Topics**

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 5013 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Campus section restricted to graduate students in EEEN or BS/Professional MS concurrent degree students with BS portion in EEEN or ECEN.

**ECEN 5016 (1-4) Special Topics**

**Additional Information:** Departmental Category: Optics

**ECEN 5018 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Dynamical Systems and Control

**ECEN 5021 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Repeatable:** Repeatable for up to 9.00 total credit hours.

**Requisites:** Restricted to graduate students in Electrical Engineering (EEEN) or in Electrical/Computer Engineering (ECEN) or to Electrical or Electrical/Computer Engineering BS/MS Concurrent degree students or to Graduate Certificate Engineering (CRTGE) students.

**Additional Information:** Departmental Category: Bioengineering

**ECEN 5023 (3) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering, Embedded Systems.

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Campus section restricted to graduate students in EEEN or BS/Professional MS concurrent degree students with BS portion in EEEN or ECEN.

**Additional Information:** Departmental Category: Embedded Systems Engineering

**ECEN 5024 (1-4) Special Topics**

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4024

**Additional Information:** Departmental Category: Electromagnetics and Remote Sensing

**ECEN 5028 (1-4) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.

**Additional Information:** Departmental Category: Dynamical Systems and Control

**ECEN 5032 (3) Special Topics**

**Additional Information:** Departmental Category: Bioengineering

**ECEN 5053 (3) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering - Embedded Engineering.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4053

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Campus section restricted to graduate students in Academic sub-plans ESE or C-EEENP or C-ECENEEEP.

**Additional Information:** Departmental Category: Embedded Systems Engineering

**ECEN 5104 (3) Computer-Aided Microwave Circuit Design**

Emphasizes the design of strip-line and microstrip circuits, using a CAD package. Discusses design of impedance transformers, amplifiers, switches, phase-shifters, etc. Assignments include design of typical circuits and their analysis using a microwave circuit analysis program. Laboratory includes measurements using a network analyzer facility on a typical circuit designed and fabricated by students.

**Requisites:** Requires a prereq course of ECEN 3410 (min grade D-). Restricted to EEEN or ECEN graduate students or Electrical Engineering Concurrent or Electrical/Computer Engineering Concurrent Degree students only.

**Additional Information:** Departmental Category: Electromagnetics and Remote Sensing

**ECEN 5107 (3) Electric Power Grid**

Examines the electrical grid, including conventional generation, transmission/ distribution, and new renewable generation technologies. Issues including grid stability, the increase in variable generation on the grid, and how the electrical grid will change in the future will be addressed. Intended for students with an engineering background from outside electrical engineering who desire an introduction to the power grid.

**Requisites:** Excludes graduate students in Electrical Engineering or Electrical Engineering Concurrent degree plans.

**Additional Information:** Departmental Category: Power

**ECEN 5114 (3) Waveguides and Transmission Lines**

Intermediate course dealing with guided-wave systems at HF, microwave, and optical frequencies. Modern waveguiding structures, including circular metallic waveguides, microstrip transmission lines, and optical waveguides are treated. Additional material may include waveguide losses, excitation of waveguides, microwave network theory, coupled-mode theory, resonators, and pulse propagation in waveguides.

**Requisites:** Requires a prereq course of ECEN 3410 (min grade D-). Restricted to EEEN or ECEN graduate students or Electrical Engineering Concurrent or Electrical/Computer Engineering Concurrent Degree students only.

**Additional Information:** Departmental Category: Electromagnetics and Remote Sensing

**ECEN 5122 (3) Wireless Local Area Networks**

Emphasis on the IEEE P802.11 family of WLAN standards. Students learn the legacy versions of the standard (802.11DS/b), the current generation of WLAN systems (802.11a/g/n/ac), and will to analyze and critique upcoming versions (802.11ax/ba), and gain insight into proposals for new research in WLAN. Exposure to the interoperability and certification process for WLAN by the Wi-Fi Alliance, study the newest Wi-Fi Certified<sub>z</sub> programs, and will learn how to model and analyze WLAN traffic using industry standard tools.

**Equivalent - Duplicate Degree Credit Not Granted:** CYBR 5220

**Requisites:** Requires prerequisite course of ECEN 3810 or APPM 3570 or MATH 4510 (minimum grade D-).

**Recommended:** Prerequisite CYBR 5430.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 5126 (3) Computational Optical Imaging**

Covers the fundamentals of computational optical imaging modalities, namely systems in which the hardware (optics, sensors, illumination) is designed in conjunction with algorithms (implemented optically, electronically and via software) to deliver information about a scene. Students learn the analysis and design of modern imaging systems. Covers a variety of applications including biomedical imaging, nanoscopy, photography and space imaging.

**Requisites:** Restricted to graduate students only.

**Grading Basis:** Letter Grade

**ECEN 5133 (3) Fundamentals of Computer Security**

Practice thinking like an attacker by exploring several modern computer security attacks and defenses through hands-on programming projects. Topics include applied cryptography (encryption, authentication), web security (XSS, CSRF, SQL Injection), network security (TLS, MITM attacks), application security (shell injection, buffer overflows), and other current events and trends (government surveillance, botnets, cryptocurrencies).

**Grading Basis:** Letter Grade



**ECEN 5134 (3) Electromagnetic Radiation and Antennas**

Covers elementary sources and antennas, cylindrical wire antennas, loop antennas, radiation patterns and antenna gain, aperture sources such as horns and dishes, specialized antennas such as microstrip patches, linear and circular arrays, mutual coupling and ground effects, ray and numerical formulations, transmission formulas, and antenna applications.

**Requisites:** Requires a prereq course of ECEN 3410 (min grade D-). Restricted to any graduate students or Electrical/Computer Engineering or Electrical Engineering Concurrent Degree majors only.  
**Additional Information:** Departmental Category: Electromagnetics and Remote Sensing

**ECEN 5138 (3) Control Systems Analysis**

Analysis and design of continuous time control systems using classical and state space methods. Laplace transforms, transfer functions and block diagrams. Stability, dynamic response, and steady-state analysis. Analysis and design of control systems using root locus and frequency response methods. Computer aided design and analysis. Topics covered in this course will be investigated in more depth, require external readings, additional homework will be assigned, and the exams will be more difficult.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4138  
**Requisites:** Restricted to graduate students in Electrical Engineering (EEEN) or in Electrical/Computer Engineering (ECEN) or to Electrical or Electrical/Computer Engineering BS/MS Concurrent degree students or to Graduate Certificate Engineering (CRTGE) students.  
**Recommended:** Prerequisite ECEN 3300.  
**Additional Information:** Departmental Category: Dynamical Systems and Control

**ECEN 5139 (3) Computer-Aided Verification**

Covers theoretical and practical aspects of verification of finite-state systems (hardware) and infinite-state systems (programs). Model checking: temporal logics, explicit-state and symbolic search, BDDs. Constraint solvers: SAT solvers, decision procedures. Program verification: invariants, partial vs. total correctness, abstraction. Department enforced requisite: general proficiency in discrete mathematics and programming.

**Equivalent - Duplicate Degree Credit Not Granted:** CSCI 5135  
**Requisites:** Restricted to Electrical/Computer Engineering (EEEN) graduate students or Concurrent Degree students in Electrical Engineering (C-EEEN) or Electrical/Computer Engineering (C-ECENEEEN) or to Graduate Certificate Engineering (CRTGE) students.  
**Recommended:** Prerequisite CSCI 2824.  
**Additional Information:** Departmental Category: VLSI CAD Methods

**ECEN 5154 (3) Computational Electromagnetics**

Provides a computational study of microwave circuits and antennas, using finite-difference, finite-element, and moment methods. Requires students to develop algorithms, write and execute programs, and prepare reports analyzing results. Circuits include waveguides, microstrip lines, and center-fed dipole antennas.

**Requisites:** Requires a prereq course of ECEN 3410 (min grade D-). Restricted to any graduate students or Electrical/Computer Engineering or Electrical Engineering Concurrent Degree majors only.  
**Additional Information:** Departmental Category: Electromagnetics and Remote Sensing

**ECEN 5156 (3) Physical Optics**

Covers the application of Maxwell's equations to optical wave propagation in free space and in media. Topics include polarization, dispersion, geometrical optics, interference, partial coherence, and diffraction.

**Requisites:** Restricted to graduate students only.  
**Recommended:** Prerequisite ECEN 3410.  
**Additional Information:** Departmental Category: Optics

**ECEN 5224 (3) High Speed Digital Design**

Covers fundamentals of high-speed properties of logic gates, measurement techniques, transmission lines, ground planes and layer stacking, terminations, vias, power systems, connectors, ribbon cables, clock distribution and clock oscillators.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4224  
**Requisites:** Requires a prereq course of ECEN 3400 (min grade D-). Restricted to any graduate students or Electrical/Computer Engineering or Electrical Engineering Concurrent Degree majors only.  
**Additional Information:** Departmental Category: Electromagnetics and Remote Sensing

**ECEN 5244 (3) Stochastic / Environmental Signal Processing**

Provides a baseline understanding for research and development in signal processing and analytics for environmental and other data-intensive applications. Topics include parameter estimation, transforms, linear and nonlinear estimation, data assimilation and detection. Applications include numerical weather prediction, GNSS sensing, ionospheric sounding, radar, radiometry, surveillance, target detection and tracking. Previous coursework in linear systems and electromagnetic waves recommended.

**Grading Basis:** Letter Grade

**ECEN 5254 (3) Remote Sensing Signals and Systems**

Examines passive and active techniques for remote sensing with emphasis on fundamental noise and detection issues from radio to optical frequencies. Emphasis is placed on electromagnetic wave detection, statistical signal and noise analysis, remote sensing system architecture, and hardware for remote sensing systems. Systems studied include radiometers, radars (real and synthetic aperture), interferometers, and lidars. Applications to detection and surveillance, Earth remote sensing, astronomy, and imaging systems are covered.

**Requisites:** Requires prerequisite courses of ECEN 3300 and ECEN 3400. Restricted to any graduate students or Electrical/Computer Engineering or Electrical Engineering Concurrent Degree majors only.  
**Additional Information:** Departmental Category: Electromagnetics and Remote Sensing

**ECEN 5264 (3) Electromagnetic Absorption, Scattering, and Propagation**

Electromagnetic waves in communication, navigation, and remote sensing systems from radio to optical frequencies, including propagation in deterministic and random media. Topics include absorption and refraction by gases, discrete scattering by precipitation, clouds, and aerosols, continuous scattering by refractivity fluctuations, earth-space propagation and Faraday rotation in plasmas, and radiative transfer theory.

**Requisites:** Restricted to Electrical/Computer Engineering (EEEN) graduate students or Concurrent Degree students in Electrical Engineering (C-EEEN) or Electrical/Computer Engineering (C-ECENEEEN) or to Graduate Certificate Engineering (CRTGE) students.  
**Recommended:** Prereqs are ECEN 3400 and ECEN 3410.  
**Additional Information:** Departmental Category: Electromagnetics and Remote Sensing

**ECEN 5273 (3) Network Systems**

Focuses on design and implementation of network programs and systems, including topics in network protocols, file transfer, client-server computing, remote procedure call and other contemporary network system design and programming techniques. Familiarity with C and Unix is required.

**Equivalent - Duplicate Degree Credit Not Granted:** CSCI 5273

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 5322 (3) Data and Network Science**

The course covers the theory and design of algorithms that are used to model, analyze, and extract information from large scale datasets and networks. The course includes a project.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 5341 (3) Bioelectromagnetics**

Effects of electric and magnetic fields on biological systems are described with applications to therapy and safety. The complexity of biological systems is described to provide a better understanding of the distribution of fields inside the body. Risk analysis is also introduced.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4341

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Bioengineering

**ECEN 5345 (3) Introduction to Solid State Physics**

Provides an introduction to the electronic, photonic and phononic properties of solid state materials and devices. Covers optical constants, free electron gas, plasmons, energy bands, semiconductors and doping, excitons, quantum wells, phonons and electrooptical effects. Makes use of quantum mechanical methods. Department enforced prerequisite: basic quantum mechanics.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Nanostructures and Devices

**ECEN 5355 (3) Principles of Electronic Devices 1**

Relates performance and limitations of solid state devices to their structures and technology. Examines semiconductor physics and technology. Includes Pn-junction, Mos, and optoelectronic devices. For both advance circuit and device engineers.

**Requisites:** Restricted to graduate students only.

**Recommended:** Prerequisite ECEN 3320.

**Additional Information:** Departmental Category: Nanostructures and Devices

**ECEN 5358 (3) Optimization and Optimal Control**

Introduces the theory and practice of optimization and optimal control. Topics include basic theory, nonlinear system trajectories and regulation, function space operators and derivatives, optimality conditions, barrier functionals and Newton's method in function space.

**Requisites:** Restricted to graduate students in Electrical Engineering (EEEN) or in Electrical/Computer Engineering (ECEN) or to Electrical or Electrical/Computer Engineering BS/MS Concurrent degree students or to Graduate Certificate Engineering (CRTGE) students.

**Recommended:** Prerequisite ECEN 5448.

**Additional Information:** Departmental Category: Dynamical Systems and Control

**ECEN 5423 (3) Chaotic Dynamics**

Explores chaotic dynamics theoretically and through computer simulations. Covers the standard computational and analytical tools used in nonlinear dynamics and concludes with an overview of leading-edge chaos research. Topics include time and phase-space dynamics, surfaces of section, bifurcation diagrams, fractal dimension and Lyapunov exponents.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4423 and CSCI 4446 and CSCI 5446

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 5448 (3) Advanced Linear Systems**

Offers a state space approach to analysis and synthesis of linear systems, state transition matrix, controllability and observability, system transformation, minimal realization, and analysis and synthesis of multi-input and multi-output systems.

**Requisites:** Restricted to Electrical/Computer Engineering (EEEN) graduate students or Concurrent Degree students in Electrical Engineering (C-EEEN) or Electrical/Computer Engineering (C-ECENEEEN) or to Graduate Certificate Engineering (CRTGE) students.

**Recommended:** Prerequisites ECEN 3300 and ECEN 4138.

**Additional Information:** Departmental Category: Dynamical Systems and Control

**ECEN 5458 (3) Sampled Data and Digital Control Systems**

Provides an analysis and synthesis of discrete-time systems. Studies sampling theorem and sampling process characterization, z-transform theory and z-transferfunction, and stability theory. Involves data converters (A/D and D/A), dead-beat design, and digital controller design.

**Requisites:** Restricted to College of Engineering graduate students only.

**Recommended:** Prerequisites ECEN 3300 and ECEN 4138.

**Additional Information:** Departmental Category: Dynamical Systems and Control

**ECEN 5517 (3) Power Electronics and Photovoltaic Power Systems Laboratory**

Focuses on analysis, modeling, design and testing of electrical energy processing systems in a practical laboratory setting. Studies power electronics converters for efficient utilization of available energy sources, including solar panels and utility. Experimental projects involve design, fabrication and testing of a solar power system.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4517

**Requisites:** Requires prerequisite course of ECEN 5797 (minimum grade C-).

**Additional Information:** Departmental Category: Power

**ECEN 5523 (3) Compiler Construction**

Introduces the principles and techniques for compiling high-level programming languages to assembly code. Topics include parsing, instruction selection, register allocation, and compiling high-level features such as polymorphism, first-class functions, and objects. Students build a complete compiler for a simple language.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4553 and CSCI 4555 and CSCI 5525

**Requisites:** Restricted to Electrical/Computer Engineering (EEEN) graduate students or Concurrent Degree students in Electrical Engineering (C-EEEN) or Electrical/Computer Engineering (C-ECENEEEN) or to Graduate Certificate Engineering (CRTGE) students.

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 5532 (3) Digital Signal Processing Laboratory**

Develops experience in code development, debugging and testing of real-time digital signal processing algorithms using dedicated hardware. Applications include filtering, signal synthesis, audio special effects and frequency domain techniques based on the Fast Fourier Transform.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4532

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 5533 (3) Fundamental Concepts of Programming Languages**

Considers concepts common to a variety of programming languages—how they are described (both formally and informally) and how they are implemented. Provides a firm basis for comprehending new languages and gives insight into the relationship between languages and machines.

**Equivalent - Duplicate Degree Credit Not Granted:** CSCI 5535

**Requisites:** Requires prerequisite course CSCI 3155 (minimum grade D-).

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 5543 (3) Software Engineering of Standalone Programs**

Applies engineering principles to phases of software product development, project planning, requirements definition, design, design patterns, validation and maintenance. Emphasizes practical methods for communicating and verifying definitions and designs: prototyping, inspections, and modeling (primarily UML). Includes relation to embedded systems and object-oriented design.

**Equivalent - Duplicate Degree Credit Not Granted:** CSCI 5548

**Requisites:** Restricted to graduate students only.

**Recommended:** Prerequisites CSCI 1300 and CSCI 2270 (minimum grade C-).

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 5555 (3) Principles of Energy Systems and Devices**

Develops principles underlying electronic, optical and thermal devices, materials and nanostructures for renewable energy. Provides a foundation in statistical thermodynamics and uses it to analyze the operation and efficiency limits of devices for photovoltaics, energy storage (batteries & ultra-capacitors), chemical conversion (fuel cells and engines), solid state lighting, heat pumps, cooling and potentially harvesting zero-point energy from the vacuum.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4555

**Requisites:** Restricted to students with 57-180 credits (Juniors or Seniors) or Graduate students only.

**Additional Information:** Departmental Category: Nanostructures and Devices

**ECEN 5573 (3) Advanced Operating Systems**

Intended to create a foundation for operating systems research or advanced professional practice. Examines the design and implementation of a number of research and commercial operating systems and their components, system organization and structure, threads, communication and synchronization, virtual memory, distribution, file systems, security and authentication, availability and Internet services.

**Equivalent - Duplicate Degree Credit Not Granted:** CSCI 5573

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 5593 (3) Advanced Computer Architecture**

Provides a broad-scope treatment of important concepts in the design and implementation of high-performance computer systems. Discusses important issues in the pipelining of a processor, out-of-order instruction issue and superscalar designs, design of cache memory systems for such systems, and architectural features required for multicore processor designs. Also studies current and historically important computer architectures.

**Equivalent - Duplicate Degree Credit Not Granted:** CSCI 5593

**Requisites:** Campus section restricted to graduate students in EEEN or BS/Professional MS concurrent degree students with BS portion in EEEN or ECEN.

**Recommended:** Prerequisite ECEN 4593.

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 5603 (3) Software Project Management**

Presents topics and techniques critical to the management of software product development, including estimating, planning, quality, tracking, reporting, team organization, people management and legal issues. Gives special attention to problems unique to software projects.

**Requisites:** Requires prerequisite courses ECEN 4583 and ECEN 5543 and CSCI 4318 (all minimum grade D-). Restricted to graduate students only.

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 5606 (3) Optics Laboratory**

Provides advanced training in experimental optics. Consists of optics experiments that introduce the techniques and devices essential to modern optics, including characterization of sources, photodetectors, modulators, use of interferometers, spectrometers, and holograms and experimentation of fiber optics and Fourier optics. Department enforced prerequisite: undergraduate optics course (e.g. PHYS 4510).

**Equivalent - Duplicate Degree Credit Not Granted:** PHYS 5606

**Additional Information:** Departmental Category: Optics

**ECEN 5612 (3) Random Processes for Engineers**

Deals with random time-varying functions and is therefore useful in the broad range of applications where they occur. Topics include review of probability, convergence of random sequences, random vectors, minimum mean-square error estimation, basic concepts of random processes, Markov processes, Poisson processes, Gaussian processes, linear systems with random inputs, and Wiener filtering. Applications range from communications, communication networks, and signal processing to random vibration/stress analysis, mathematical finance, physics, etc.

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 5613 (3) Embedded System Design**

Introduces system hardware and firmware design for embedded applications. Students independently design and develop a hardware platform encompassing a microcontroller and peripherals. Firmware is developed in C and assembly. A significant final project is designed, developed, documented and presented. Prioritized for EEEN graduate students with ESE (Embedded Systems Engineering) sub-plan.

**Requisites:** Campus section restricted to graduate students in Academic sub-plans ESE or C-EEENP or C-ECENEEEP.

**Additional Information:** Departmental Category: Embedded Systems Engineering

**ECEN 5616 (3) Optoelectric System Design**

Examines optical components and electro-optic devices with the goal of integrating into well design optoelectronic systems. Sample systems include optical storage, zoom lenses and telescopes.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4616

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Optics

**ECEN 5622 (3) Information Theory and Coding**

Covers fundamental limits of data compression, reliable transmission of information and information storage. Topics include information measures, typicality, entropy rates of information sources, limits and algorithms for lossless data compression, mutual information, and limits of information transmission over noisy wired and wireless links. Optional topics include lossy data compression, limits of information transmission in multiple-access and broadcast networks, and limits and algorithms for information storage.

**Requisites:** Restricted to Electrical/Computer Engineering, Computer Science, Applied Math or Physics graduate students only.

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 5623 (3) Real-Time Embedded Systems**

Design and build a microprocessor-based embedded system application requiring integration of sensor/actuator devices, a real-time operating system and application firmware and software. Real-time rate monotonic theory and embedded architecture are covered. Prioritized for EEEN graduate students with ESE (Embedded Systems Engineering) sub-plan.

**Requisites:** Campus section restricted to graduate students in Academic sub-plans ESE or C-EEENP or C-ECENEEEP.

**Additional Information:** Departmental Category: Embedded Systems Engineering

**ECEN 5626 (3) Active Optical Devices**

Analysis of active optical devices such as semiconductor laser, detector and flat panel display by clearly defining and interconnecting the fundamental physical mechanism, device design and operating principles and device performance.

**Requisites:** Restricted to graduate students only.

**Recommended:** Prerequisite ECEN 5355.

**Additional Information:** Departmental Category: Optics

**ECEN 5632 (3) Theory and Application of Digital Filtering**

Digital signal processing and its applications are of interest to a wide variety of scientists and engineers. The course covers such topics as characterization of linear discrete-time circuits by unit pulse response, transfer functions, and difference equations, use of z-transforms and Fourier analysis, discrete Fourier transform and fast algorithms (FFT), design of finite and infinite impulse response filters, frequency transformations, study of optimized filters for deterministic signals.

**Requisites:** Restricted to Electrical/Computer Engineering (EEEN) graduate students or Concurrent Degree students in Electrical Engineering (C-EEEN) or Electrical/Computer Engineering (C-ECENEEEN) or to Graduate Certificate Engineering (CRTGE) students.

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 5634 (3) Microwave and RF Laboratory**

Introduce RF and microwave measurement methods. A laboratory course whose experiments build on material learned in ECEN 3410: electromagnetic waves, transmission lines, waveguides, time-domain reflection, frequency-domain measurement, microwave networks, impedance matching, antenna pattern measurement, radar and simple nonlinear concepts such as harmonics, square-law detection, mixing and transmitter/receiver applications.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4634

**Requisites:** Requires a prereq course of ECEN 3410 (min grade D-).

Restricted to any graduate students or Electrical/Computer Engineering or Electrical Engineering Concurrent Degree majors only.

**Additional Information:** Departmental Category: Electromagnetics and Remote Sensing

**ECEN 5645 (3) Introduction to Optical Electronics**

Introduces lasers, Gaussian optics, modulators, nonlinear optics, optical detectors, and other related devices.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Nanostructures and Devices

**ECEN 5652 (3) Detection and Extraction of Signals from Noise**

Introduces detection, estimation, and related algorithms. Topics in detection include simple/composite hypothesis testing, repeated observations and asymptotic performance and sequential detection. Topics in estimation include Bayesian estimation including minimum mean-square estimation and non-random parameter estimation. Topics in algorithms vary. Examples include algorithms for state estimation and smoothing in Hidden Gauss-Markov models and the expectation-maximization algorithm. Applications include communications, radar/sonar/geophysical signal processing, image analysis, authentication, etc.

**Requisites:** Restricted to Electrical/Computer Engineering, Computer Science, Applied Math or Physics graduate students only.

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 5672 (3) Digital Image Processing**

Course objective is to present the fundamental techniques available for image representation and compression (e.g., wavelets), filtering (e.g., Wiener and nonlinear filter), and segmentation (e.g., anisotropic diffusion).

**Requisites:** Requires prerequisite course ECEN 5632 (minimum grade C-).

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 5673 (3) Distributed Systems**

Examines systems that span multiple autonomous computers. Topics include system structuring techniques, scalability, heterogeneity, fault tolerance, load sharing, distributed file and information systems, naming, directory services, resource discovery, resource and network management, security, privacy, ethics and social issues.

**Equivalent - Duplicate Degree Credit Not Granted:** CSCI 5673

**Recommended:** Prerequisite CSCI 5573 or a course in computer networks.

**Additional Information:** Departmental Category: Computer and Digital Systems



**ECEN 5683 (3) Programmable Logic Embedded System Design**

Learn to design programmable systems on a chip for the purpose of creating prototypes or products for a variety of applications. Explores complexities, capabilities and trends of Field Programmable Gate Arrays (FPGA) and Complex Programmable Logic Devices (CPLD). Implement synchronization and timing closure in these devices. Projects will involve the latest software and FPGA development tools and hardware platforms.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Embedded Systems Engineering

**ECEN 5692 (3) Principles of Digital Communication**

Introduces fundamental principles of efficient and reliable transmission of information used in wired and wireless digital communication systems including cable modems, smart phones/tablets, cellular networks, local area (wi-fi) networks, and deep-space communications. Topics include bandwidth and power constraints, digital modulation methods, optimum transmitter and receiver design principles, error rate analysis, channel coding potential in wired/wireless media, trellis coded modulation, and equalization.

**Requisites:** Restricted to Electrical/Computer Engineering (EEEN) graduate students or Concurrent Degree students in Electrical Engineering (C-EEEN) or Electrical/Computer Engineering (C-ECENEEEN) or to Graduate Certificate Engineering (CRTGE) students.

**Additional Information:** Departmental Category: Digital Signal Processing Communications

**ECEN 5696 (3) Fourier Optics**

Introduces a system level approach to the analysis and design of optical systems. Topics include holography, Fourier transform properties of lenses, two-dimensional convolution and correlation functions, spatial filtering and optical computing techniques. Also covers coherent and incoherent imaging techniques, tomography, and synthetic aperture imaging.

**Requisites:** Restricted to graduate students only.

**Recommended:** Prerequisites ECEN 3300 and ECEN 3410.

**Additional Information:** Departmental Category: Optics

**ECEN 5737 (3) Adjustable-Speed AC Drives**

Presents unified treatment of complete electrical drive systems: mechanical load, electrical machine, power converter, and control equipment. Emphasizes induction, synchronous, and permanent-magnet drives. Uses simulation programs (e.g., SPICE, Finite Element/Difference Program) to simulate drive system components (e.g., gating, inverter, electric machine).

**Requisites:** Restricted to Electrical/Computer Engineering (EEEN) graduate students or Concurrent Degree students in Electrical Engineering (C-EEEN) or Electrical/Computer Engineering (C-ECENEEEN) or to Graduate Certificate Engineering (CRTGE) students.

**Recommended:** Prerequisite ECEN 3170.

**Additional Information:** Departmental Category: Power

**ECEN 5738 (3) Theory of Nonlinear Systems**

Nonlinear systems and control. Introduction to nonlinear phenomena: multiple equilibria, limit cycles, bifurcations, complex dynamical behavior. Planar dynamical systems, analysis using phase plane techniques. Input-output analysis and stability. Passivity. Lyapunov stability theory. Feedback linearization. Exploration of examples and applications. Formerly ECEN 7438.

**Requisites:** Requires prerequisite course of ECEN 5448 (minimum grade C-). Restricted to graduate students in Electrical Engr (EEEN) or Electrical/Computer Engr (ECEN) or Electrical Engr Concurrent or Electrical/Computer Engr Concurrent Degree students only.

**Additional Information:** Departmental Category: Dynamical Systems and Control

**ECEN 5753 (3) Computer Performance Modeling**

Presents a broad range of system modeling techniques, emphasizing applications to computer systems. Covers stochastic processes, queuing network models, stochastic Petri nets and simulation (including parallel processing techniques). Also requires second-semester calculus.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4753 and CSCI 4753 and CSCI 5753

**Additional Information:** Departmental Category: Computer and Digital Systems

**ECEN 5763 (3) Embedded Machine Vision and Intelligent Automation**

Introduces students to machine vision and machine learning methods used in automation, autopilots and security and inspection systems. Embedded and automation topics include implementation of algorithms with FPGA or GP-GPU embedded real time co-processing for autopilots (intelligent transportation), general automation and security including methods for detection, classification, recognition of targets for inspection, surveillance, search and rescue, and machine vision navigation applications.

**Requisites:** Campus section restricted to graduate students in Academic sub-plans ESE or C-EEENP or C-ECENEEEP.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Embedded Systems Engineering

**ECEN 5773 (3) Developing the Industrial Internet of Things**

This course goes beyond consumer IoT hype to emphasize a much greater space for potential embedded system applications and growth: The Industrial Internet of Things (IIoT), also known as Industry 4.0. Cisco's CEO stated: "IoT overall is a \$19 Trillion market. IIoT is a significant subset including digital oilfield, advanced manufacturing, power grid automation, and smart cities". The course examines emerging markets, technology trends, applications and skills required for exploring career opportunities in this space.

**Requisites:** Restricted to students with an Embedded Systems Engineering (ESE) subplan or Electrical Engr-Prof Degree (C-EEENP) or Elec Cmp Elec Eng-Prof Degree (C-ECENEEENP) only.

**Recommended:** Prerequisites ECEN 5613, ECEN 5823, ECEN 5053, and ECEN 5133.

**ECEN 5783 (3) Embedded Interface Design**

This course deeply explores interface design approaches and architectures for creating embedded system prototypes and products. For both machine and user interfaces, we will examine best practices for the interface design process, including considerations of characteristics of the information to be transferred between devices or between a device and a user. Projects leverage the now standard Raspberry Pi 3 single-board computer (SBC), providing a strong foundation for exploring many elements of interface design.

**Requisites:** Restricted to students with an Embedded Systems Engineering (ESE) subplan or Electrical Engr-Prof Degree (C-EEENP) or Elec Cmp Elec Eng-Prof Degree (C-ECENEENP) only.

**Recommended:** Prerequisites knowledge of programming, particularly Python, ECEN 2120, ECEN 2350, ECEN 1030, ECEN 1310, CSCI 1300.

**ECEN 5797 (3) Introduction to Power Electronics**

An introduction to switched-mode converters. Includes steady-state converter modeling and analysis, switch realization, discontinuous conduction mode and transformer-isolated converters. Ac modeling of converters using averaged methods, small-signal transfer functions, feedback loop design and transformer design.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4797

**Requisites:** Restricted to Electrical/Computer Engineering (EEEN) graduate students or Concurrent Degree students in Electrical Engineering (C-EEEN) or Electrical/Computer Engineering (C-ECENEEN) or to Graduate Certificate Engineering (CRTGE) students.

**Additional Information:** Departmental Category: Power

**ECEN 5803 (3) Mastering Embedded Systems Architecture**

Acquire an understanding of embedded systems architectures for the purpose of creating prototypes or products for a variety of applications. The salient issues in the decision making process will be examined, including trade-offs between hardware and software implementations, processor and operating system selection and IP creation or acquisition. Projects will involve the latest software development and tools and hardware platforms.

**Requisites:** Campus section restricted to graduate students in Academic sub-plans ESE or C-EEENP or C-ECENEENP.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Embedded Systems Engineering

**ECEN 5807 (3) Modeling and Control of Power Electronic Systems**

Studies modeling and control topics in power electronics. Averaged switch modeling of converters, computer simulation, ac modeling of the discontinuous conduction mode, the current programmed mode, nulldouble injection techniques in linear circuits, input filter design, and low-harmonic rectifiers.

**Requisites:** Requires prerequisite course of ECEN 5797 (minimum grade C-).

**Additional Information:** Departmental Category: Power

**ECEN 5813 (3) Principles of Embedded Software**

Introduces principles around embedded software elements and software development needed for the Embedded Systems Engineering core curriculum. Student will write C program applications that employ efficient, high performance and robust software design techniques. Topics include bare-metal firmware, c-programming optimization and introductions to underlying embedded architecture. Sound testing and debug practices will be instilled and utilized in several application projects.

**Requisites:** Campus section restricted to graduate students in Academic sub-plans ESE or C-EEENP or C-ECENEENP.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Embedded Systems Engineering

**ECEN 5817 (3) Resonant and Soft-Switching Techniques in Power Electronics**

Covers resonant converters and inverters, and soft switching; sinusoidal approximations in analysis of series, parallel, LCC, and other resonant dc-dc and dc-ac converters; state-plane analysis of resonant circuits; switching transitions in hard-switched and soft-switched PWM converters; zero-voltage switching techniques, including resonant, quasi resonant, zero voltage transition, and auxiliary switch circuits.

**Requisites:** Requires prerequisite course of ECEN 5797 (minimum grade C-).

**Additional Information:** Departmental Category: Power

**ECEN 5821 (3) Neural Systems and Physiological Control**

A biophysical exploration of human physiology from the standpoints of control systems and neural information processing. Topics include: neural control of movement and cardiovascular performance, tissue growth and repair, carcinogenesis, and physiological responses to microgravity.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4821 and ASEN 4426 and ASEN 5426

**Additional Information:** Departmental Category: Bioengineering

**ECEN 5823 (3) Internet of Things Embedded Firmware**

Acquire firmware development skills to meet low energy and internet connectivity demands of embedded systems. Event-driven firmware techniques will be explored through programming assignments, transitioning to programming an Internet of Things RF Network Protocol such as Bluetooth Low Energy or Thread. The coursework will align with the latest industry firmware and embedded wireless protocol trends.

**Requisites:** Campus section restricted to graduate students in Academic sub-plans ESE or C-EEENP or C-ECENEENP.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Embedded Systems Engineering

**ECEN 5827 (3) Analog IC Design**

Covers the fundamentals of transistor-level analog integrated circuit design. Starting with motivations from application circuits, the course develops principles of dc biasing, device models, amplifier stages, frequency response analysis and feedback and compensation techniques for multi-stage operational amplifiers.

**Equivalent - Duplicate Degree Credit Not Granted:** ECEN 4827

**Requisites:** Restricted to Electrical/Computer Engineering (EEEN) graduate students or Concurrent Degree students in Electrical Engineering (C-EEEN) or Electrical/Computer Engineering (C-ECENEEN) or to Graduate Certificate Engineering (CRTGE) students.

**Additional Information:** Departmental Category: Power

**ECEN 5830 (3) Special Topics**

Examines a special topic in Electrical, Computer and Energy Engineering.  
**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: General

**ECEN 5833 (3) Low Power Embedded Design Techniques**

The course explores through weekly quizzes, assignments, and a course project, low energy hardware design concepts, selecting components to meet reliability goals, radio implementation, power supply design, product design, and system bring up. The programming of the microcontroller or SoC will most likely be coding to the metal to control individual microcontroller peripherals and utilizing them in the most energy efficient ways.

**Requisites:** Restricted to students with an Embedded Systems Engineering (ESE) subplan or Electrical Engr-Prof Degree (C-EEENP) or Elec Cmp Elec Eng-Prof Degree (C-ECENEENP) only.

**Recommended:** Requisites Students should have knowledge of assembly and C programming, digital logic design, and embedded computer architecture, and have had at least one course in each of these subjects, such as ECEN 5813 or ECEN 5823, students should also have experience using a microcontroller Integrated Development Environment (IDE) and its associated tools including its debugger and register views.

**ECEN 5837 (3) Mixed-Signal IC Design Lab**

Software laboratory course extends the concepts developed in ECEN 5827 to full design and layout of mixed analog and digital custom integrated circuits. Assignments explore implementation of analog to digital and digital to analog converters, and final project develops a full custom IC for a target application.

**Requisites:** Requires prerequisite course of ECEN 5827 (minimum grade C-).

**Additional Information:** Departmental Category: Power

**ECEN 5840 (1-6) Independent Study**

Offers an opportunity for students to do independent, creative work at the master's level. Numbered ECEN 5840-5849. Department consent required.

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: General

**ECEN 5853 (3) Embedding Sensors and Motors**

Introduces students to the design of sensors and motors, and methods that integrate them into embedded systems used in consumer and industrial products. Students will learn about sensor technologies and motors through lectures, recorded and online videos, online reading, and through laboratory experiments. Students will build systems that take sensor inputs, and sort, filter and evaluate the resulting data. They will also learn how to use sensor input to measure properties of motors.

**Requisites:** Restricted to students with an Embedded Systems Engineering (ESE) subplan or Electrical Engr-Prof Degree (C-EEENP) or Elec Cmp Elec Eng-Prof Degree (C-ECENEENP) only.

**Recommended:** Prerequisites ECEN 1400, ECEN 2250, ECEN 2260 and ECEN 2440 or equivalent coursework.

**ECEN 5863 (3) Programmable Logic Embedded System Design**

Learn to design programmable systems on a chip for the purpose of creating prototypes or products for a variety of applications. Explore complexities, capabilities and trends of Field Programmable Gate Arrays (FPGA) and Complex Programmable Logic Devices (CPLD). Implement synchronization and timing closure in these devices. Projects will involve the latest software and FPGA development tools and hardware platforms.

**Requisites:** Campus section restricted to graduate students in Academic sub-plans ESE or C-EEENP or C-ECENEENP.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Embedded Systems Engineering

**ECEN 5907 (3) Special Topics**

Special topics class.

**Repeatable:** Repeatable for up to 3.00 total credit hours. Allows multiple enrollment in term.

**ECEN 6016 (1-3) Special Topics**

**Additional Information:** Departmental Category: Optics

**ECEN 6139 (3) Logic Synthesis of VLSI Systems**

Studies synthesis and optimization of sequential circuits, including retiming transformations and don't care sequences. Gives attention to hardware description languages and their application to finite state systems. Also includes synthesis for testability and performance, algorithms for test generation, formal verification of sequential systems, and synthesis of asynchronous circuits.

**Recommended:** Prerequisites ECEN 5139 and CSCI 5454.

**Additional Information:** Departmental Category: VLSI CAD Methods

**ECEN 6144 (3) Electromagnetic Boundary Problems**

Provides mathematical and physical fundamentals necessary for the systematic analysis of electromagnetic fields problems. Covers basic properties of Maxwell's equations, potentials and jump conditions; scattering and diffraction by canonical structures; Green's functions, integral equations and approximate methods. Requires some maturity in electromagnetics.

**Requisites:** Requires prereq course of ECEN 5114 or 5134 (minimum grade C-). Restricted to graduate students in Electrical Engr (EEEN) or Electrical/Computer Engr (ECEN) or Electrical Engr Concurrent or Electrical/Computer Engr Concurrent Degree students only.

**Additional Information:** Departmental Category: Electromagnetics and Remote Sensing

**ECEN 6800 (3) Master of Engineering Report**

**Additional Information:** Departmental Category: General

**ECEN 6940 (1) Master's Candidate for Degree**

**Grading Basis:** Pass/Fail

**Additional Information:** Departmental Category: General

**ECEN 6950 (1-6) Master's Thesis**

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: General

**ECEN 6960 (3) Master of Engineering**

**Additional Information:** Departmental Category: General

**ECEN 7840 (1-6) Independent Study**

Offers an opportunity for students to do independent, creative work at the doctoral level. Department consent required.

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: General

**ECEN 7849 (1-6) Independent Study**

Offers an opportunity for students to do independent, creative work at the doctoral level. Department consent required.

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: VLSI CAD Methods

**ECEN 8990 (1-10) Doctoral Thesis**

**Repeatable:** Repeatable for up to 10.00 total credit hours.

**Additional Information:** Departmental Category: General