

ELECTRICAL, COMPUTER & ENERGY ENGINEERING

Electrical engineering offers study of the basic science and technology of information and energy. Its areas of knowledge include:

- information theory and communications systems
- computers and digital systems
- signal processing and instrumentation
- feedback systems and automatic control
- electrical and electronic devices and systems
- power electronics and renewable energy
- electromagnetics and microwave devices
- optics and photonic systems
- embedded systems engineering

Students learn how this basic knowledge is applied to such modern technologies as computers, telecommunications, biomedical systems and remote sensing. The curriculum accommodates a variety of student interests including design, production, testing, consulting services, research, teaching and management. Graduates pursue careers in a large variety of fields in the computer, telecommunications, instrumentation, biomedical, aerospace, energy, materials and semiconductors industries, as well as academia. Some go on to careers in other professions such as law or medicine.

Electrical and computer engineering offers the same curriculum as electrical engineering, except that required courses in computer hardware and software replace some upper-division electives. As with electrical engineering, it accommodates broad student interests from design to service, and from research to management. Its graduates take positions in fields as diverse as those listed above for electrical engineering.

Course code for this program is ECEN.

Bachelor's Degree

- Electrical and Computer Engineering - Bachelor of Science (BSEC) (<https://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/electrical-computer-energy-engineering/electrical-computer-engineering-bachelor-science-bsec/>)
- Electrical Engineering - Bachelor of Science (BSEE) (<https://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/electrical-computer-energy-engineering/electrical-engineering-bachelor-science-bsee/>)

Minor

- Computer Engineering - Minor (<https://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/electrical-computer-energy-engineering/computer-engineering-minor/>)
- Electrical Engineering - Minor (<https://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/electrical-computer-energy-engineering/electrical-engineering-minor/>)
- Quantum Engineering - Minor (<https://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/>)

[programs-study/electrical-computer-energy-engineering/quantum-engineering-minor/](https://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/electrical-computer-energy-engineering/quantum-engineering-minor/))

- Signals and Systems - Minor (<https://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/electrical-computer-energy-engineering/signals-systems-minor/>)

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member's home department.

Akos, Dennis M. (https://experts.colorado.edu/display/fisid_131119/)
Professor; PhD, Ohio University

Anderson, Dana Z. (https://experts.colorado.edu/display/fisid_102371/)
Professor; PhD, University of Arizona

Baker, Kyri A. (https://experts.colorado.edu/display/fisid_159754/)
Assistant Professor; PhD, Carnegie Mellon University

Barnes, Frank S. (https://experts.colorado.edu/display/fisid_104148/)
Distinguished Professor Emeritus; PhD, Stanford University

Barton, Taylor Wallis (https://experts.colorado.edu/display/fisid_157939/)
Faculty Fellow, Associate Professor; DSc, Massachusetts Institute of Technology

Becker, Stephen R. (https://experts.colorado.edu/display/fisid_154263/)
Associate Professor; PhD, California Institute of Technology

Blum, Arielle Melissa (https://experts.colorado.edu/display/fisid_154695/)
Instructor; MS, University of Colorado Boulder

Bogatin, Eric (https://experts.colorado.edu/display/fisid_151431/)
Lecturer; PhD, University of Arizona

Brancucci, Carlo
Lecturer; PhD, Technische Universiteit Delft (Netherlands)

Bright, Victor Mark (https://experts.colorado.edu/display/fisid_112696/)
Professor; PhD, Georgia Institute of Technology

Carter Carston, Ronald McKell (https://experts.colorado.edu/display/fisid_154921/)
Assistant Professor; PhD, California Institute of Technology

Chang, Bor-Yuh Evan (https://experts.colorado.edu/display/fisid_146087/)
Associate Professor; PhD, University of California, Berkeley

Chaudhary, Sumeet (https://experts.colorado.edu/display/fisid_167980/)
Instructor; PhD, University of Cincinnati

Chen, Xudong (https://experts.colorado.edu/display/fisid_158323/)
Assistant Professor; PhD, Harvard University, Cambridge, MA

Clauset, Aaron (https://experts.colorado.edu/display/fisid_147554/)
Associate Professor; PhD, University of New Mexico

Cogswell, Carol (https://experts.colorado.edu/display/fisid_141919/)
Research Professor; MArch, University of Oregon

Combes, Josh (https://experts.colorado.edu/display/fisid_166284/)
Assistant Professor; PhD, Griffith University

Corradini, Luca (https://experts.colorado.edu/display/fisid_146380/)
Associate Professor, Visiting Associate Professor; PhD, University of Padova (Italy)

Correll, Nikolaus J. (https://experts.colorado.edu/display/fisid_147555/)
Associate Professor; PhD, Ecole Polytech Federale de Lausanne (Switzerland)

Dall'Anese, Emiliano (https://experts.colorado.edu/display/fisid_158949/)
Assistant Professor; PhD, University of Padova (Italy)

Diddams, Scott A. (https://experts.colorado.edu/display/fisid_148274/)
Visiting Professor, Professor Adjoint; PhD, University of New Mexico

Erickson, Robert W. (https://experts.colorado.edu/display/fisid_105514/)
Professor; PhD, California Institute of Technology

Femrite, Andrew
Senior Instructor, Faculty Director; BS, University of Colorado Boulder

Fiez, Terri S. (https://experts.colorado.edu/display/fisid_156578/)
Professor; PhD, Oregon State University

Filipovic, Dejan S. (https://experts.colorado.edu/display/fisid_126278/)
Professor; PhD, University of Michigan Ann Arbor

Gasiewski, Albin J. (https://experts.colorado.edu/display/fisid_142882/)
Professor; PhD, Massachusetts Institute of Technology

Gopinath, Juliet T. (https://experts.colorado.edu/display/fisid_147075/)
Professor; PhD, Massachusetts Institute of Technology

Grunwald, Dirk C. (https://experts.colorado.edu/display/fisid_102261/)
Professor; PhD, University of Illinois at Urbana–Champaign

Hauser, John (https://experts.colorado.edu/display/fisid_102555/)
Associate Professor; PhD, University of California, Berkeley

Heckman, Christoffer (https://experts.colorado.edu/display/fisid_155294/)
Assistant Professor; PhD, Cornell University

Herzfeld, Ute C. (https://experts.colorado.edu/display/fisid_106575/)
Research Professor; PhD, Johannes Gutenberg-Universität Mainz (Germany)

Hodge, Bri-Mathias (https://experts.colorado.edu/display/fisid_158358/)
Associate Professor; PhD, Purdue University

Huang, Shu-Wei (https://experts.colorado.edu/display/fisid_159847/)
Assistant Professor; PhD, MIT, Cambridge

Izraelevitz, Joe (https://experts.colorado.edu/display/fisid_166042/)
Assistant Professor; PhD, University of Rochester

Kapteyn, Henry C. (https://experts.colorado.edu/display/fisid_115334/)
Professor; PhD, University of California, Berkeley

Keller, Eric Robert (https://experts.colorado.edu/display/fisid_151647/)
Associate Professor; PhD, Princeton University

Kuester, Edward F.
Professor Emeritus

Lasser, Gregor (https://experts.colorado.edu/display/fisid_156178/)
Assistant Research Professor; PhD, Technische Universität Wien (Austria)

Le, Hanh-Phuc
Assistant Professor; PhD, University of California, Berkeley

Lehman, Tamara (https://experts.colorado.edu/display/fisid_165649/)
Assistant Professor; PhD, Duke University

Lightner, Michael R. (https://experts.colorado.edu/display/fisid_101723/)
Professor; PhD, Carnegie Mellon University

Liu, Youjian (https://experts.colorado.edu/display/fisid_126283/)
Associate Professor; PhD, Ohio State University

MacCurdy, Robert B. (https://experts.colorado.edu/display/fisid_163307/)
Assistant Professor; PhD, Cornell University

Majerfeld, Arnaldo
Professor Emeritus

Maksimovic, Dragan (https://experts.colorado.edu/display/fisid_105609/)
Professor; PhD, California Institute of Technology

Mathys, Peter (https://experts.colorado.edu/display/fisid_100084/)
Associate Professor; PhD, ETH Zürich (Switzerland)

McAuliffe, Rik
Lecturer

McClure, Linden
Professor Adjunct

McLeod, Robert R. (https://experts.colorado.edu/display/fisid_107547/)
Professor; PhD, University of Colorado Boulder

Mendelson, Jay
Lecturer

Mickelson, Alan R. (https://experts.colorado.edu/display/fisid_100286/)
Associate Professor; PhD, California Institute of Technology

Mihran, Richard
Professor Adjunct

Mishra, Shivakant (https://experts.colorado.edu/display/fisid_118376/)
Professor; PhD, University of Arizona

Moddel, Garret (https://experts.colorado.edu/display/fisid_105440/)
Professor; PhD, Harvard University

Murnane, Margaret (https://experts.colorado.edu/display/fisid_115333/)
Distinguished Professor; PhD, University of California, Berkeley

Nicotra, Marco M. (https://experts.colorado.edu/display/fisid_164182/)
Assistant Professor; PhD, Université Libre de Bruxelles

Palo, Scott E. (https://experts.colorado.edu/display/fisid_109033/)
Professor; PhD, University of Colorado Boulder

Pao, Lucy Y. (https://experts.colorado.edu/display/fisid_107151/)
Professor; PhD, Stanford University

Park, Won (https://experts.colorado.edu/display/fisid_122676/)
Professor, Associate Chair; PhD, Georgia Institute of Technology

Perkins, Mike
Lecturer; PhD, Stanford University

Piestun, Rafael (https://experts.colorado.edu/display/fisid_118538/)
Professor; PhD, Israel Instit of Tech (Israel)

Piket-May, Melinda J. (https://experts.colorado.edu/display/fisid_102097/)
Associate Professor; PhD, Northwestern University

Pleszkun, Andrew R.
Professor Emeritus

Popovic, Zoya (https://experts.colorado.edu/display/fisid_101494/)
Distinguished Professor; PhD, California Institute of Technology

Poveda, Jorge
Assistant Professor

Psychogiou, Dimitra (https://experts.colorado.edu/display/fisid_158311/)
Assistant Professor; PhD, ETH Zürich (Switzerland)

Sankaranarayanan, Sriram (https://experts.colorado.edu/display/fisid_147413/)
Professor; PhD, Stanford University

Scherr, Timothy (https://experts.colorado.edu/display/fisid_156259/)
Senior Instructor; MS, University of Utah

Schibli, Thomas Richard (https://experts.colorado.edu/display/fisid_143464/)
Professor; PhD, Univ of Karlsruhe (Germany)

Shaheen, Sean Eric (https://experts.colorado.edu/display/fisid_153664/)
Professor; PhD, University of Arizona

Sheafor, Steve
Lecturer; PhD, University of Illinois

Siewert, Sam
Associate Professor Adjunct

Sluiter, David
Professor Adjunct; BS, Michigan Technological University

Somenzi, Fabio (https://experts.colorado.edu/display/fisid_103969/)
Professor, Associate Chair; PhD, Politecnico Di Torino (Italy)

Spriggs, Benjamin
Lecturer, Scholar in Residence

Thayer, Jeffrey P. (https://experts.colorado.edu/display/fisid_134469/)
Professor; PhD, University of Michigan Ann Arbor

Trivedi, Ashutosh (https://experts.colorado.edu/display/fisid_156589/)
Assistant Professor; PhD, University of Warwick (UK)

Van Zeghbroeck, Bart J. (https://experts.colorado.edu/display/fisid_104113/)
Professor, Associate Chair; PhD, University of Colorado Boulder

Varanasi, Mahesh K. (https://experts.colorado.edu/display/fisid_103090/)
Professor; PhD, Rice University

Wagner, Kelvin (https://experts.colorado.edu/display/fisid_105344/)
Professor; PhD, California Institute of Technology

Walkes, Dan
Lecturer

Williamson, James A.
Lecturer

Wustrow, Eric A. (https://experts.colorado.edu/display/fisid_156419/)
Assistant Professor; BE, University of Michigan Ann Arbor

Zabotin, Nikolay
Research Professor; DSc, Russian Academy of Science

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 using the C language. Teaches the use of pointers, control flow, aggregate types, input/output, heap-allocated memory, and abstract data types. Includes a weekly computer lab session.

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

Requisites: Restricted to College of Engineering (ENGRU) undergraduates and IUT On Track applicants only.

Recommended: Prerequisite APPM 1350.

Additional Information: Departmental Category: General

ECEN 1400 (3) Introduction to Digital and Analog Electronics

This course introduces students to electrical and computer engineering centered around creative projects in a team based setting. Through the design and implementation of functional engineering systems, students gain an understanding of the engineering design process, using real-world design tools such as prototyping, computer-aided design (CAD), 3D printing, laser cutting, printed circuit board (PCB) manufacturing and testing. The projects-based curriculum provides students with a basis in the fundamentals of analog and digital electronics with an emphasis of developing student's understanding of how the electronics and software operate within an interdisciplinary context. Students gain hands-on experience with the creation of systems using sensors, actuators, programming microcontrollers, prototyping circuits using breadboards, and designing systems. No prior experience or knowledge of electronics or software is required.

Equivalent - Duplicate Degree Credit Not Granted: ASTR 2500, GEEN 1400, ASEN 1400 and ASE

Requisites: Restricted to students with 0-56 credits (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 Reasn 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

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

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 (3) Special Topics

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

Repeatable: Repeatable for up to 6.00 total credit hours.

Recommended: Prerequisite or corequisite PHYS 1140.

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 pre OR corequisite course of (APPM 2360 or MATH 3430). Restricted to College of Engineering majors or IUT On Track applicants or Electrical Eng minors.

Recommended: Prerequisites 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 or MATH 3430) (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 2350 (4) 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). This course is 3 lectures and 1 lab per week.

Requisites: Requires prerequisite course of ECEN 1310 or CSCI 1300 or CSCI 1320 or ASEN 1320 (minimum grade C-). Restricted to College of Engineering majors or IUT On Track applicants.

Additional Information: Departmental Category: General

ECEN 2360 (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.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 3350

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

ECEN 2370 (3) Embedded Software Engineering

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, featuring ARM processors, embedded and mobile computing platforms, using the C programming language.

Requisites: Requires prerequisite courses of ECEN 1310 and ECEN 2350 and prerequisite or corequisite course of ECEN 2360 (all minimum grade C-).

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 prerequisite OR 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 prerequisite course of ECEN 2250 (min grade C-). 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 or CSCI 1300 or CSCI 1320 or ASEN 1320 (minimum grade C-). Requires prerequisite OR corequisite course of ECEN 2250.

Additional Information: Departmental Category: General

ECEN 2450 (3) Electronic and Semiconductor Device Laboratory

Explores the operation of electronic and semiconductor devices, including: resistors, transparent conductors, capacitors, inductors, diodes and light emitting diodes, photovoltaics, photodiodes, bipolar junction and field effect transistors, organic electrochemical transistors, and various sensor devices. Laboratories will involve device characterization and implementation into simple circuits, data analysis, and function fitting. Some of the laboratories will involve partial fabrication of the devices. Previously offered as a special topics course. Recommended restriction: sophomores or juniors; seniors cannot enroll in the course.

Requisites: Requires prerequisite or corequisite course of ECEN 2250 (minimum grade C-). Restricted to College of Engineering students only.

Recommended: Prerequisite PHYS 1140.

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) Special Topics

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

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 and a prereq or coreq course of APPM 2360 or APPM 3310 or MATH 3430 (all min grade C-). Restricted to MCEN or EVEN or Integrated Design Engr (IDEN-BSIDE) students.

Additional Information: Departmental Category: General

ECEN 3090 (3) Introduction to Quantum Computing

Covers the basics of quantum computation, including the basics of quantum information; axioms of quantum mechanics; quantum circuits and universality; the relationship between quantum and classical complexity classes; simple quantum algorithms such as the quantum Fourier transform; Shor factoring algorithm; Grover search algorithm; physical implementation of quantum computation; error correction and fault tolerance.

Equivalent - Duplicate Degree Credit Not Granted: CSCI 3090 and PHYS 3090

Requisites: Requires prerequisite course of APPM 2360 or APPM 3310 or CSCI 2820 or MATH 2130 or MATH 2135 (minimum grade C-).

ECEN 3103 (3) Automation of Industrial Processes

Introduces students to Programmable Logic Controller (PLC) architecture, ladder logic programming, and programming Human Machine Interfaces (HMI). Students learn how to automate manufacturing processes and applications of PID control.

Requisites: Requires prerequisite course of ECEN 2250 (minimum grade D-). Restricted to students in the CMU/CU-Boulder Engineering Partnership Program only.

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 2250 (minimum grade C-). Restricted to College of Engineering students 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.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 3301

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

Additional Information: Departmental Category: General

ECEN 3301 (3) Biomedical Signals and Systems

Introduces theory and methods to characterize and process biological signals from a variety of sources and engineering applications in the time and frequency domains. This course covers mathematical and computational tools for signal analysis with emphasis on discrete time signals and digital processing. Topics include noise, sampling, Fourier transforms, filter design, LTI systems, and image processing with exercises in MATLAB.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 3300

Requisites: Requires prerequisite course of ECEN 2260 (minimum grade C-).

Recommended: Prerequisite BMEN 3030.

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 and CSPB 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 2250 (minimum grade C-). Restricted to College of Engineering students 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.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 2360

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 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 3593 (3) Computer Organization

Studies computer design at the microarchitecture 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 hardware security.

Equivalent - Duplicate Degree Credit Not Granted: CSCI 3593 ECEN 5590

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 3730 (3) Practical Printed Circuit Board Design and Manufacture

This course prepares students with all skills needed to convert a back-of-the-napkin circuit sketch into a working widget with first time success. Students will master the seven steps in every board project: planning, selecting components, schematic entry, layout, assembly, bring up and debug, and documentation. This process will be exercised with three different board design projects with increasing challenge. A commercial EDA tool widely used in the electronics industry will be used for all projects. Previously offered as a special topics course. Formerly ECEN 4730.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 4720 or ECEN 5720 or ECEN 5730

Requisites: Requires prerequisite courses of ECEN 2250 and ECEN 2260 and ECEN 2270 (all minimum grade C-).

ECEN 3753 (3) Real-Time Operating Systems

Today's electronic systems require real-time management and scheduling of hardware resources alongside complex multi-threaded software applications. This course covers what is an Operating Systems, the development of multi-threaded applications, and satisfying real-time system obligations. Real-Time profiling tools will be used to learn and visualize how the operating system is scheduling the software tasks and hardware resources to meet resource constraint embedded system applications. Formerly offered as a special topics course.

Requisites: Requires prerequisite course (ECEN 2370 or ECEN 3360) and CSCI 2270 (all minimum grade C-). Restricted to College of Engineering students only.

ECEN 3763 (3) FPGA Design and HDL

Build upon the foundations of Digital Logic to learn the theory of FPGA architectures, design practices, and design processes. The emphasis is to architect and design complex FPGA based projects demonstrating overall project organization and creation of milestones, testing requirements, proper use of physical and design constraints, and successful implementation and demonstration. Previously offered as a special topics course.

Requisites: Requires prerequisite courses of ECEN 2350 and (ECEN 1310 or CSCI 1300 or ASEN 1320) (minimum grade C-). Restricted to College of Engineering students only.

Recommended: Prerequisites ECEN 2360 and ECEN 2370.

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 3915 (3) Foundations of Quantum Engineering

Introduces engineers to quantum theory. In this course you will learn how to describe many different physical systems (such as atoms, electrons, light, mechanical oscillators, and tops) mathematically. It also explores different notions of quantumness such as entanglement and non-contextuality. The foundations obtained in this course are important for further study of quantum hardware (sensors), communication, and computing. Formerly ECEN 4915.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 5915

Requisites: Requires prerequisite courses of (ASEN 1320 OR ECEN 1310 OR ECEN 2310 OR CSCI 1300 OR APPM 3050 OR PHYS 2600) (MATH 3135 OR MATH 2130 OR MATH 2135 OR APPM 2360 OR APPM 3310 OR CSCI 2820) all minimum grade C-.

Recommended: Prerequisite MATH 3430 or APPM 2360.

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 (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 4006 (3) 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 (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: 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
Repeatable: Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.
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 4111 (3) Engineering Applications in Biomedicine: Cardiovascular Devices and Systems

Application of engineering in medicine has grown dramatically in recent years. Engineers enter the clinical and experimental medical arenas with many new devices and procedures emerging as alternatives to conventional surgical and pharmacological treatments. This course, presents general principles of biomedical engineering as applied to the development of a variety of specific devices and techniques for therapy and diagnosis, with a focus on devices and systems for the cardiovascular system. This class will present relevant anatomy and physiology as part of the class discussion, which will be supplemented by a physiology reference text. Questions, exchanges of ideas, and active classroom discussion are encouraged. Biomedical engineering is an emerging field which is highly interdisciplinary- engineers and scientists from all fields are invited and encouraged to participate in this course. There are no formal prerequisites.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 5111

Recommended: Prerequisite ECEN 2250 or equivalent circuits course.

ECEN 4121 (3) Design of Implantable Medical Devices: Neuromodulation

Application of engineering in medicine has grown dramatically in recent years. Engineers enter the clinical and experimental medical arenas with many new devices and procedures emerging as alternatives to conventional surgical and pharmacological treatments. This course, presents general principles of biomedical engineering as they are applied to the development of a variety of specific implantable devices. It will present relevant anatomy and physiology as part of the class discussion, which will be supplemented by a physiology reference text. Questions, exchanges of ideas, and active classroom discussion are encouraged throughout the course. Biomedical engineering is an emerging field which is highly interdisciplinary- engineers and scientists from all fields are invited and encouraged to participate in this course.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 5121

Recommended: Prerequisite ECEN 2250 or equivalent circuits course.

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).

Equivalent - Duplicate Degree Credit Not Granted: CSCI 4133

Requisites: Requires prerequisite courses of CSCI 2270 and ECEN 2360 or CSCI 2400 or ECEN 3350 (all minimum grade C-).

Recommended: Corequisite ECEN 3593 (Computer Organization).

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 MCEN 4138 or MCEN 5138

Requisites: Requires prerequisite course of ECEN 3300 or MCEN 4043 (minimum grade C-). Restricted to College of Engineering majors only.

Additional Information: Departmental Category: Dynamical Systems and Control

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 prerequisites of ECEN 2260 and ECEN 3400 (minimum grade C-). Restricted to College of Engineering students 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 or ECEN 3301) and (ECEN 3810 or APPM 3570 or MATH 4510 or STAT 3100) (all minimum grade C-). Restricted to College of Engineering majors only.

Additional Information: Departmental Category: Digital Signal Processing Communications

ECEN 4295 (3) Foundations of Quantum Hardware

Introduces students to the principles and operation of quantum hardware. In this course you will learn how to describe many different physical systems (trapped ions, superconducting circuits, and optical systems) mathematically. This will allow you to model quantum sensors, communication systems and computing hardware.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 5295

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).

Equivalent - Duplicate Degree Credit Not Granted: CSCI 4313 and ECEN 5313 and CSCI 5313

Requisites: Requires prerequisite courses of CSCI 2270 and (ECEN 2360 or ECEN 3350 or CSCI 2400) (minimum grade C-). Restricted to College of Engineering students only.

Recommended: Prerequisite ECEN 3593.

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.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 5322

Requisites: Prereq of (APPM 2350 or MATH 2400) (APPM 2360 or MATH 3430) (CSCI 1200 or CSCI 1300 or CSCI 1320 or ECEN 1310 or ASEN 1320 or INFO 1201 or ATLS 1300 or CHEN 1310) (ECEN 2703 or CSCI 2824 or APPM 3170 or MATH 2001) (min grade C-). Restricted to ENGR mjrs

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 or STAT 3100) (all minimum grade C-). Restricted to College of Engineering students only.

Additional Information: Departmental Category: Bioengineering

ECEN 4395 (3) Organic Electronic Materials and Devices

Covers the materials and physics principles of organic electronic devices, including organic light emitting diodes (OLEDs), photovoltaics (OPVs), field effect transistors (OFETs), electrochemical transistors (OECTs), and bioelectronic and neuromorphic devices. The molecular, structural, and electronic properties of organic semiconductors are introduced, and the architectures and operating principles of the devices are then taught.

Assignments will require computational solutions and simulations. Previously offered as a special topics course.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 5395

Recommended: Prerequisite ECEN 5345.

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 or ASEN 1320) and PHYS 1110 (all minimum grade C-). Restricted to College of Engineering students only.

Recommended: Prerequisites PHYS 1120 and CSCI 3656 and (APPM 3310 or CSCI 2820 or MATH 2130 or MATH 2135 or MATH 3130 or MATH 3135).

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 or APPM 3170 or CSCI 2824 or MATH 2001) and (ECEN 2360 or ECEN 3350 or CSCI 2400) (all minimum grade C-). Restricted to College of Engineering students 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 or STAT 3100) and (PHYS 2130 or PHYS 2170) (all minimum grade C-). Restricted to College of Engineering students only.

Additional Information: Departmental Category: Nanostructures and Devices

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-. IDEN majors follow different requisites and should work with their advisor for requisite planning and enrollment assistance.

Requisites: Prereqs of ECEN 2270, ECEN 2370, (ECEN 2360 or CSCI 2400) and (ECEN 3250 and ECEN 3300) or (ECEN 3250 and ECEN 3400) or (ECEN 3300 and ECEN 3400) or (ECEN 3753 and ECEN 3250) or (ECEN 3753 and ECEN 3300) or (ECEN 3753 and ECEN 3400) (all min grade C-).

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 ECEN or EEEN or C-EEEN or C-ECENEEEN or C-EEENP or C-ECENEEEP or IDEN-BSIDE 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

This course is a hands-on introduction to RF and microwave topics, from fundamentals including vector network analyzer (VNA) calibration and operation, power measurements, and antenna characterization, to system-level topics such as RADAR systems and superheterodyne links. Students work in small groups on weekly experiments based on both coaxial and waveguide setups. An understanding of electromagnetic waves (such as covered in ECEN 3400 and ECEN 3410) is assumed. The graduate version of the course (ECEN 5634) includes additional homework and exam problems and extended laboratory exercises compared to ECEN 4634.

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.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 5638

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 4693 (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: ECEN 5593 and CSCI 5593

Requisites: Requires prerequisite course of ECEN 3593 (minimum grade C-)

Recommended: Prerequisite knowledge of C/C++ and Assembly programming languages, and computer organization and experience using a Linux system for programming and its associated capabilities of compilation and debugging.

ECEN 4720 (1) Practical Printed Circuit Board Design Accelerator

This course introduces students to the most important skills needed to convert a back-of-the-napkin circuit sketch into a working widget with first time success. Students will learn the seven steps in every board project: planning, selecting components, schematic entry, layout, assembly, bring up and debug, and documentation. This process will be exercised with a custom board design project. A commercial EDA tool widely used in the electronics industry will be used for the project. Previously offered as a special topics course.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 5720 ECEN 3730 or ECEN 5730

Requisites: Requires prerequisite courses of ECEN 2250 and ECEN 2260 and ECEN 2270 (all minimum grade C-).

ECEN 4752 (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. Formerly ECEN 4652.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 5752

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 or ECEN 3753 (minimum grade C-). Restricted to College of Engineering students only.

Recommended: Prerequisite a course in statistics.

Additional Information: Departmental Category: Computer and Digital Systems

ECEN 4763 (3) Embedded Software Algorithms

Embedded Systems are defined by resource restrictions that could include computational performance, energy, memory space, and cost. These algorithms need to be evaluated against the targeted end-system constraints. Applications in many areas of real-time decision-making are discussed, from hybrid vehicle battery usage to queue management systems in real-time-priced tollways, aircraft holding patterns, and hard disk drive performance optimization. This is a programming course.

Requisites: Requires prerequisite courses of (ECEN 2370 or ECEN 3360) and CSCI 2270 (all minimum grade C-). Restricted to College of Engineering students only.

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 4925 (3) Foundations of Quantum Hardware

Introduces students to the principles and operation of quantum hardware. In this course you will learn how to describe many different physical systems (trapped ions, superconducting circuits, and optical systems) mathematically. This will allow you to model quantum sensors, communication systems and computing hardware.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 5295

Requisites: Requires prerequisite course of ECEN 3915 OR (prerequisite of PHYS 3220 AND corequisite of PHYS 4410) (all minimum grade C-).

Restricted to College of Engineering students only.

ECEN 4933 (3) Engineering Genetic Circuits

Presents recent research into methods and software tools for the modeling, analysis, and design of genetic circuits that are enabling the new field of synthetic biology. Teaches both biological and engineering principles in order to enable collaborations between engineers and biologists working in the field of synthetic biology.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 5933

Recommended: Prerequisite some familiarity with genetics, cell biology, molecular biology or biochemistry or familiarity with engineering methods for modeling, analysis and design, but students are not expected to have knowledge in both.