Rose-Hulman Institute of Technology Course Catalog

Computer Engineering - Course Descriptions

**ECE 160 Engineering Practice 0R-4L-2C F,W**
**Prerequisites:** There are no prerequisites for this course.
**Corequisites:** There are no corequisites for this course.
An introduction to electrical and computer engineering, systems engineering design, programming, microcontrollers, soldering and circuit building. Students will work individually and on teams to complete projects and create a system for an end of term competition. Students will also learn about technical documentation and communication. Topics include functions, arrays, conditionals, loops, Boolean algebra, wireless communication, resistors, transistors, diodes motors, sensor, analog and digital inputs and outputs.

**ECE 180 Introduction to Signal Processing 3R-3L-4C F,W,S**
**Prerequisites:** MA 112 Calculus II 5R-0L-5C F,W,S, and ECE 160 Engineering Practice 0R-4L-2C F,W or CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S or prior programming experience
**Corequisites:** There are no corequisites for this course.
An introduction to discrete-time signal processing applied to audio, images, and video. Topics include phasor representation of sinusoidal signals, complex arithmetic, sampling, signal spectra, linear time-invariant systems, frequency response, convolution, filter implementation, and MATLAB programming. Integral laboratory.

**ECE 203 DC Circuits 3R-3L-4C S, F**
**Prerequisites:** MA 111 Calculus I 5R-0L-5C F,W, and PH 112 Physics II 3.5R-1.5L-4C W,S,F
**Corequisites:** There are no corequisites for this course.
A review of the definition of voltage, current, energy and power. An introduction to Ohm’s Law, ideal DC independent and dependent voltage and current sources, resistors, inductors, capacitors, and operational amplifiers. Circuit analysis and simplification by using series, parallel, and Wye-Delta reduction, Kirchhoff’s laws, mesh and nodal analysis, Thevenin, Norton and Maximum Power Theorems, superposition, and source transformations. An integral laboratory to build electric circuits and measure voltage, current, resistance and power.

**ECE 204 AC Circuits 3R-3L-4C F,W**
**Prerequisites:** PH 113 Physics III 3.5R-1.5L-4C S,F,W, and either ECE 203 DC Circuits 3R-3L-4C S, F* or ES 203 Electrical Systems 3R-3L-4C F,W,S* or ES 213 Electrical Systems 3R-0L-3C F,W,S*, and ES 213L Electrical Systems Lab 0R-3L-1C F,W,S* *with a grade of C or better
**Corequisites:** There are no corequisites for this course.
ECE 205 Circuits & Systems 3R-3L-4C W,S
Prerequisites: MA 211 Differential Equations 4R-0L-4C F,W,S, and ECE 180 Introduction to Signal Processing 3R-3L-4C F,W,S, and RH 131 Rhetoric & Composition 4R-0L-4C F,W,S, and either ECE 203 DC Circuits 3R-3L-4C S, F* or ES 203 Electrical Systems 3R-3L-4C F,W,S* or ES 213 Electrical Systems 3R-0L-3C F,W,S*, and ES 213L Electrical Systems Lab 0R-3L-1C F,W,S* *with a grade of C or better
Corequisites: There are no corequisites for this course.

ECE 206 Elements of Electrical Engineering 4R-0L-4C W,S
Prerequisites: MA 211 Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
A course designed for engineers (other than electrical or computer) covering analysis of passive circuits, introduction to op-amps, instrumentation, sinusoidal steady-state, a-c power, and induction motors. EE and CPE majors may not take this course.

ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S
Prerequisites: ECE 233 Introduction to Digital Systems 3R-3L-4C F,W, CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S, and ECE 160 Engineering Practice 0R-4L-2C F,W
Corequisites: There are no corequisites for this course.

ECE 233 Introduction to Digital Systems 3R-3L-4C F,W
Prerequisites: CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S or ECE 160 Engineering Practice 0R-4L-2C F,W
Corequisites: There are no corequisites for this course.
Number systems, Binary arithmetic, logic gates, forming logic circuits. Boolean algebra, Karnaugh maps. Propagation delay, hazards, common Combinational logic circuits, structures, and design. Contraction, latches, flip-flops, finite state machines, counters, Sequential circuit timing, and designing Sequential circuits. Register design, control and datapath design. Basic computer architecture, including memory. Integral laboratory.

ECE 250 Electronic Device Modeling 3R-3L-4C S,F
Prerequisites: ECE 204 AC Circuits 3R-3L-4C F,W or ECE 205 Circuits & Systems 3R-3L-4C W,S, ES 203 Electrical Systems 3R-3L-4C F,W,S* or ES 213 Electrical Systems 3R-0L-3C F,W,S*, and ES 213L Electrical Systems Lab 0R-3L-1C F,W,S* *with grade of B or better
Corequisites: There are no corequisites for this course.
Modeling, analysis, and simulation of electronic circuits that contain two-terminal and three-terminal semiconductor devices. Large-signal, biasing, and small-signal analysis models. Introduction to wave shaping circuits, switching circuits, and amplifiers. Integral laboratory.

ECE 300 Continuous-Time Signals & Systems 3R-3L-4C F,W,S
Prerequisites: ECE 205 Circuits & Systems 3R-3L-4C W,S, and MA 211 Differential Equations 4R-0L-4C F,W,S, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Signal modeling. Fourier series and Fourier transforms. Response of systems to periodic and aperiodic signals. Filter characterization and design. Ideal and practical sampling. Use of numerical analysis software. Integral laboratory

ECE 310 Communication Systems 3R-3L-4C F, S
Prerequisites: ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
Transmission of information over bandlimited, noisy communication channels. Line codes, probability of error, intersymbol interference. Modulation techniques, synchronization and frequency conversion. Integral laboratory.

ECE 312 Communication Networks 4R-0L-4C W
Prerequisites: MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S, and CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.

ECE 320 Linear Control Systems 3R-3L-4C W,S
Prerequisites: ECE 300 Continuous-Time Signals & Systems 3R-3L-4C F,W,S, and ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S or ME 430 Mechatronic Systems 3R-3L-4C F,W
Corequisites: There are no corequisites for this course.

ECE 332 Computer Architecture II 4R-0L-4C S
Prerequisites: CSSE 232 Computer Architecture I 3R-3L-4C F,W
Corequisites: There are no corequisites for this course.

ECE 340 Electromagnetic Fields 4R-0L-4C F,W
Prerequisites: ECE 204 AC Circuits 3R-3L-4C F,W, and MA 211 Differential Equations 4R-0L-4C F,W,S, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Maxwell’s equations. Introduction to electromagnetic waves. Use of vector calculus and numeric approximation. Technical reports and/or term papers.

**ECE 341 Electromagnetic Waves 4R-0L-4C W,S**
Prerequisites: ECE 340 Electromagnetic Fields 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.

**ECE 342 Introduction to Electromagnetic Compatibility 3R-3L-4C F,S**
Prerequisites: ECE 300 Continuous-Time Signals & Systems 3R-3L-4C F,W,S and Computer Engineering Major
Corequisites: There are no corequisites for this course.

**ECE 343 High-Speed Digital Design 3R-3L-4C F,S**
Prerequisites: ECE 300 Continuous-Time Signals & Systems 3R-3L-4C F,W,S and Computer Engineering Major
Corequisites: There are no corequisites for this course.
Signal path modeling through connecting lengths of transmission lines with lumped element models of discontinuities. Circuit parameters from geometries and material properties for resistance, capacitance, inductance and transmission line segments. Lossless and lossy transmission line circuit modeling. High-frequency and high-speed behavior of passive components. Frequency spectrum of digital signals. Digital device driver and receiver modeling. Transmission line impedance discontinuity and termination techniques. Electric and magnetic field coupling mechanisms for capacitive and inductive crosstalk. Ground noise, power plane noise and resonance. Signal and power integrity issues in high-speed digital systems at both the printed-circuit board and chip levels.

**ECE 351 Analog Electronics 3R-3L-4C F,W**
Prerequisites: ECE 205 Circuits & Systems 3R-3L-4C W,S, and ECE 250 Electronic Device Modeling 3R-3L-4C S,F
Corequisites: There are no corequisites for this course.
Amplifier design and analysis including discrete and integrated circuit topologies. Cascaded amplifier, input and output stages, frequency response. Linear and non-linear op-amp circuits. Introduction to the non-ideal properties of op-amps. Integral laboratory.

**ECE 362 Principles of Design 3R-0L-3C W,S**
Prerequisites: ECE 204 AC Circuits 3R-3L-4C F,W, and ECE 205 Circuits & Systems 3R-3L-4C W,S, ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S, and ECE 233 Introduction to Digital Systems 3R-3L-4C F,W, and ECE 250 Electronic Device Modeling 3R-3L-4C S,F, and ECE 300 Continuous-Time Signals & Systems 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
A formal design course that emphasizes the design process. Project management, project reporting and decision-making are learned by student teams as they carry a project through several stages of a formal design process.

**ECE 370 Power & Energy Systems 3R-3L-4C W,S**
**Prerequisites:** ECE 204 AC Circuits 3R-3L-4C F,W
**Corequisites:** There are no corequisites for this course.
Analysis of generation systems consisting of: modeling of synchronous and induction generators, examination of fossil, nuclear, hydroelectric, solar, and wind technologies. Analysis of transmission and distribution systems consisting of modeling: power transformers, transmission lines, switchgear, and protection systems. Analysis of customer systems consisting of modeling: induction motors, linear and non-linear loads.

**ECE 371 Sustainable Energy Systems 3R-3L-4C W,S**
**Prerequisites:** ECE 204 AC Circuits 3R-3L-4C F,W
**Corequisites:** There are no corequisites for this course.
Conventional and modern sources of energy for power generation in electric power industry with the imposed economic, regulatory, and environmental constraints. Wind, solar-photovoltaic, micro-hydropower, and fuel cell systems. Integral laboratory.

**ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W**
**Prerequisites:** ECE 300 Continuous-Time Signals & Systems 3R-3L-4C F,W,S, and MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S
**Corequisites:** There are no corequisites for this course.

**ECE 398 Undergraduate Projects 1-4C**
**Prerequisites:** Arranged Prereq: Consent of instructor
**Corequisites:** There are no corequisites for this course.
Special design or research projects.

**ECE 412 Software Defined Radio 3R-3L-4C S**
**Prerequisites:** ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W, and ECE 310 Communication Systems 3R-3L-4C F, S consent of instructor
**Corequisites:** There are no corequisites for this course.
A software-defined radio (SDR) is characterized by its flexibility: Simply modifying software can completely change the radio’s functionality. This course addresses many of the choices an SDR designer must make to build a complete digital radio. Topics could include: modeling corruption, (de)modulation, AGC, filtering, bits to symbols, carrier and timing recovery, pulse shaping, equalization, coding, noise figure for the RF front end, and clock-jitter of the A/D. In the integral laboratory students will use LabVIEW to create a complete digital radio using the NI USRP 2920 platform.

**ECE 414 Wireless Systems 4R-0L-4C W**
**Prerequisites:** ECE 310 Communication Systems 3R-3L-4C F, S
**Corequisites:** There are no corequisites for this course.
Introduction to wireless communications and networks. Wireless channel models, vector space, modulation and demodulation, optimal receiver design, equalization, channel capacity, multipleaccess techniques, spread spectrum, and multiple-antenna systems. Additional recommended prerequisite: MA371 or MA373 with a grade of B or higher.
ECE 415 Wireless Electronics 2R-6L-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Design, fabrication, and testing of a high frequency transmitter-receiver system including but not limited to oscillators, mixers, filters, amplifiers, and matching networks. Integral laboratory.

ECE 416 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Prerequisites: Junior or Senior standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with CHE 405, EP 410, and ME 416.

ECE 418 Fiber Optic Systems 4R-0L-4C S
Prerequisites: ECE 310 Communication Systems 3R-3L-4C F, S Consent of instructor
Corequisites: There are no corequisites for this course.
Analysis and design of common photonic systems such as fiber optic communication links, optical sensing systems, and optical networks. Topics include basic architectures, component overview, system design, and expected degradations along with mitigation techniques. An oral presentation of a technical paper is required.

ECE 419 Advanced MEMS: Modeling and Packaging 3R-3L-4C F
Prerequisites: EP 410 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S or equivalent course
Corequisites: There are no corequisites for this course.

ECE 420 Discrete-Time Control Systems 4R-0L-4C F
Prerequisites: ECE 320 Linear Control Systems 3R-3L-4C W,S or ME 406 Control Systems 3R-3L-4C F
Corequisites: There are no corequisites for this course.
Sampled systems and z-transforms. Transfer function and state-variable models of systems. Discrete-time control of systems including state variable feedback and observer construction.

ECE 425 Introduction to Mobile Robotics 3R-3L-4C W
Prerequisites: CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S, and ECE 320 Linear Control Systems 3R-3L-4C W,S or ME 406 Control Systems 3R-3L-4C F or BE 350 Biocontrol Systems 4R-0L-4C F or CHE 440 Process Control 4R-0L-4C W
Corequisites: There are no corequisites for this course.
This course will introduce the basic principles of mobile robotics history, theory, hardware and control. Topics will include robot components, effectors and actuators, locomotion, sensors, feedback control, control architectures, representation, localization and navigation. This is a project-oriented course and the student will have hands-on
experience with a real mobile robot. The student will be required to complete several
laboratory assignments and a multidisciplinary team design project.

**ECE 430 Microcontroller-Based Systems 3R-3L-4C F**
**Prerequisites:** ECE 250 Electronic Device Modeling 3R-3L-4C S,F* *For ECE students,
consent of instructor for other students.
**Corequisites:** There are no corequisites for this course.
Microcontroller register set, addressing modes and instruction set. Microcontroller
peripheral support modules. Assembly language and C programming. Fundamental
data structures. Interrupts. Real time programming. Data communications.
Microcontroller interface to displays, digital and analog devices, sensors, and actuators.
Embedded system design, implementation and applications. Integrated development
environment. Formal final report and oral presentation. Integral laboratory. Credit cannot
be obtained for both ECE 331 and ECE 430.

**ECE 433 Advanced Digital System Design with Verilog 3R-3L-4C F**
**Prerequisites:** ECE 233 Introduction to Digital Systems 3R-3L-4C F,W
**Corequisites:** There are no corequisites for this course.
Concepts and designs of combinational and sequential digital systems; Modern
design methodology; ASM and ASMD charts for behavioral modeling; Synthesizable
Verilog descriptions and synthesis techniques; Design verification and functional
simulations; FPGA implementations of digital systems; Timing analysis and constraints;
Storage devices; Implementation options; I/O clocking techniques; Synchronous and
asynchronous designs; Complex digital systems; IP core applications. Integrated
Development Environment. Integral laboratory.

**ECE 434 Embedded Linux 3R-3L-4C W**
**Prerequisites:** CSSE 332 Operating Systems 4R-0L-4C W,S or ECE 230 Introduction
to Embedded Systems 3R-3L-4C W,S with a grade of B or better; or graduate standing,
Operating Systems and Linux experience.
**Corequisites:** There are no corequisites for this course.
Brief introduction to Linux on an embedded processor. Software development in various
languages (C, shell scripts, Python, JavaScript, etc.). Hardware interfacing. Kernel
development. Software tools (IDE, gcc, make, node.js, etc.)

**ECE 452 Power Electronics 3R-3L-4C F**
**Prerequisites:** ECE 250 Electronic Device Modeling 3R-3L-4C S,F
**Corequisites:** There are no corequisites for this course.
Analysis and design of networks that use electronic devices as power switches. Silicon-
controlled rectifiers, power transistors, and power MOSFETS are used to form phase-
controlled rectifiers, AC voltage controllers, choppers, and inverters. Integral laboratory.

**ECE 454 System Level Analog Electronics 3R-3L-4C W**
**Prerequisites:** ECE 351 Analog Electronics 3R-3L-4C F,W
**Corequisites:** There are no corequisites for this course.
Analysis and design of Op-Amp circuits: wave shaping circuits, Schmitt triggers, power
amplifiers, high power buffers, controlled current sources, peak detectors, sample and
laboratory.

**ECE 460 Engineering Design I 1R-6L-3C F**
**Prerequisites:** ECE 362 Principles of Design 3R-0L-3C W,S, and either ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S*, and ECE 310 Communication Systems 3R-3L-4C F, S*, and ECE 320 Linear Control Systems 3R-3L-4C W,S*, and ECE 341 Electromagnetic Waves 4R-0L-4C W,S*, and ECE 351 Analog Electronics 3R-3L-4C F,W*, and ECE 370 Power & Energy Systems 3R-3L-4C W,S* or ECE 371 Sustainable Energy Systems 3R-3L-4C W,S*, and ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W* or CSSE 332 Operating Systems 4R-0L-4C W,S**, and CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S**, and ECE 250 Electronic Device Modeling 3R-3L-4C S,F**, and ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S**, and ECE 312 Communication Networks 4R-0L-4C W**, and ECE 332 Computer Architecture II 4R-0L-4C S**, and ECE 343 High-Speed Digital Design 3R-3L-4C F,S**, and either ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W** or ECE 320 Linear Control Systems 3R-3L-4C W,S** *For EE: Prereq or concurrent registration in the remainder of course. **For CPE: Prereq or concurrent registration in the remainder of course.

**Corequisites:** There are no corequisites for this course.

A continuation of a sequence of formal design courses that emphasizes completion of a client-driven project using a formal design process. Student teams carry a project from inception to completion to satisfy the need of a client. Integral laboratory.

**ECE 461 Engineering Design II 1R-9L-4C W**

**Prerequisites:** ECE 460 Engineering Design I 1R-6L-3C F

**Corequisites:** There are no corequisites for this course.

Continuation of the design project from ECE460. Integral laboratory.

**ECE 462 Engineering Design III 1R-3L-2C W,S**

**Prerequisites:** ECE 461 Engineering Design II 1R-9L-4C W

**Corequisites:** There are no corequisites for this course.

Completion of the design project from ECE 460 and ECE 461. Integral laboratory.

**ECE 466 Consulting Engineering Seminar 2R-0L-2C**

**Prerequisites:** Junior class standing

**Corequisites:** There are no corequisites for this course.

Discussion problems in the field of consulting engineering; seminars presented by practicing consulting engineers. Cross-listed with BE 400, ME 420, CHE 420, and CE 420.

**ECE 470 Power Systems I 3R-3L-4C F**

**Prerequisites:** ECE 370 Power & Energy Systems 3R-3L-4C W,S

**Corequisites:** There are no corequisites for this course.


**ECE 471 Industrial Power Systems 4R-0L-4C W**

**Prerequisites:** ECE 370 Power & Energy Systems 3R-3L-4C W,S

**Corequisites:** There are no corequisites for this course.

Design and analysis techniques for low and medium voltage power distribution systems. Harmonics, transients, system coordination, reliability and economics. A design project is carried throughout the course.
ECE 472 Power Systems II 3R-3L-4C S  
Prerequisites: ECE 470 Power Systems I 3R-3L-4C F  
Corequisites: There are no corequisites for this course.  
Power system protection and stability. Design and application of relaying schemes for protection of transformers, buses, distribution lines, transmission lines, generators, motors, capacitors, and reactors. Power system stability and generator rotor dynamics phenomenon with use of the equal-area criterion. Integral laboratory.

ECE 473 Control of Power Systems 3R-3L-4C W  
Prerequisites: Senior standing or consent of instructor  
Corequisites: There are no corequisites for this course.  

ECE 480 Introduction to Image Processing 3R-3L-4C W  
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S  
Corequisites: There are no corequisites for this course.  
Basic techniques of image processing. Discrete and continuous two dimensional transforms such as Fourier and Hotelling. Image enhancement through filtering and histogram modification. Image restoration through inverse filtering. Image segmentation including edge detection and thresholding. Introduction to image encoding. Relevant laboratory experiments.

ECE 481 Electronic Music Synthesis 4R-0L-4C S  
Prerequisites: ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W  
Corequisites: There are no corequisites for this course.  

ECE 483 DSP System Design 3R-3L-4C F  
Prerequisites: ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W, and MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S  
Corequisites: There are no corequisites for this course.  
Study of finite word length effects in DSP systems. Cascaded filter structures. Coefficient quantization, roundoff noise, scaling for overflow prevention. Discrete-time noise, filtering noise, power spectral density. Polyphase filtering, interpolation and decimation. Implementation and system design and test issues for a SSB communication system. Integral laboratory based on a fixed point programming project.

ECE 497 Special Topics in Electrical Engineering 1-4C  
Prerequisites: Arranged prerequisite consent of instructor and department head  
Corequisites: There are no corequisites for this course.  
Topics of current interest to undergraduate students.

ECE 498 Undergraduate Projects 1-4C  
Prerequisites: Arranged prerequisite consent of instructor  
Corequisites: There are no corequisites for this course.  
Special design or research projects.
ECE 510 Error Correcting Codes 4R-0L-4C F (odd years)
Prerequisites: ECE 310 Communication Systems 3R-3L-4C F, S* *Graduate standing or with a grade of B or better, or consent of instructor
Corequisites: There are no corequisites for this course.
Coding for reliable digital communication. Topics to be chosen from: Hamming and BCH codes, Reed-Solomon codes, convolutional codes, Viterbi decoding, turbo codes, and recent developments, depending on interests of class and instructor. Mathematical background will be developed as needed.

ECE 511 Data Communications 4R-0L-4C F (even years)
Prerequisites: ECE 310 Communication Systems 3R-3L-4C F, S*, and MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S* or ECE 310 Communication Systems 3R-3L-4C F, S**, and MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S** *Graduate standing **with a grade of B or better in both courses, or consent of instructor
Corequisites: There are no corequisites for this course.
Design of digital communication systems. Autocorrelation function and power spectrum, vector space models of signals and noise, optimal receiver structures and performance, bandlimited channels and equalization, convolutional coding.

ECE 512 Probability, Random Processes, and Estimation 4R-0L-4C W
Prerequisites: MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S, and ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
Review of probability and random variables, random vectors, topics in estimation and detection theory, linear and nonlinear estimation, orthogonality principle, hypothesis testing, random processes, stationarity, correlation functions, and spectra. Additional topics chosen from Wiener and Kalman filtering, and Markov chains.

ECE 516 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Prerequisites: Junior or Senior class standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with BE 516, CHE 505, EP 510, and ME 516.

ECE 519 Advanced MEMS: Modeling & Packaging 3R-3L-4C F
Prerequisites: EP 410 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S or equivalent course
Corequisites: There are no corequisites for this course.

ECE 523 Advanced Topics in Computer Architecture 4R-0L-4C W
Prerequisites: ECE 332 Computer Architecture II 4R-0L-4C S with a B or better.
Corequisites: There are no corequisites for this course.

**ECE 530 Advanced Microcomputers 3R-3L-4C S**

**Prerequisites:** ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S* *Graduate standing; or with a grade of B or better; or consent of instructor

**Corequisites:** There are no corequisites for this course.

32-bit microcontroller architecture. Software development in both assembly language and C language. Hardware interfacing. Use of a real-time-operating system (RTOS). System-on-a-chip (SOC) hardware/software design using a field programmable gate array (FPGA) chip containing an embedded microcontroller cores. Software debugging tools. Integral laboratory.

**ECE 531 Digital Test & Product Engineering 3R-3L-4C S**

**Prerequisites:** ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S*, and ECE 233 Introduction to Digital Systems 3R-3L-4C F,W*, and ECE 250 Electronic Device Modeling 3R-3L-4C S,F* *Graduate standing; or with grades of B or better in all three courses; or consent of instructor.

**Corequisites:** There are no corequisites for this course.

Industrial testing techniques for microcontrollers and other digital integrated circuits. Includes common digital system fault modeling, test generation, and design for testability in addition to memory testing strategies. Integral labs using an industrial grade automatic test environment (ATE).

**ECE 534 Advanced Signal & Power Integrity 4R-0L-4C W**

**Prerequisites:** ECE 341 Electromagnetic Waves 4R-0L-4C W,S* and ECE 342 Introduction to Electromagnetic Compatibility 3R-3L-4C F,S* or ECE 343 High-Speed Digital Design 3R-3L-4C F,S* *Graduate standing; or all courses with a grade of B or better; or ECE342 with a grade of B or better, or consent of instructor

**Corequisites:** There are no corequisites for this course.


**ECE 540 Antenna Engineering 3R-3L-4C W**

**Prerequisites:** ECE 341 Electromagnetic Waves 4R-0L-4C W,S* Graduate standing (course not required); *or with a grade of B or better; or consent of instructor.

**Corequisites:** There are no corequisites for this course.

Electromagnetic radiation, antenna terminology and characteristics, dipole antennas, arrays, aperture antennas, measurements, computer-aided analysis, design projects and reports.
ECE 541 Microwave/Millimeter-Wave Engineering 4R-0L-4C S
Prerequisites: ECE 341 Electromagnetic Waves 4R-0L-4C W,S Graduate standing; or with grade of B or better, or consent of instructor
Corequisites: There are no corequisites for this course.
Wave-guiding structures, microwave network analysis, scattering parameters, Z, Y and ABCD parameters, passive devices and components, design, fabrication, simulation and measurement of microwave devices and components, matching strategies, multi-conductor transmission lines and crosstalk.

ECE 542 Advanced Electromagnetics 4R-0L-4C F
Prerequisites: ECE 341 Electromagnetic Waves 4R-0L-4C W,S and Graduate standing; or with grade of B or better, or consent of instructor
Corequisites: There are no corequisites for this course.
Maxwell’s equations, EM field theorems, potential functions, power and energy, material properties, wave propagation, reflection and transmission, radiation, scattering, Green’s functions, metamaterials and metamaterial-inspired structures, modeling & simulation, measurement technique.

ECE 543 Electromagnetic Metamaterials 4R-0L-4C
Prerequisites: ECE 341 Electromagnetic Waves 4R-0L-4C W,S* Graduate standing (course not required) *or with grade of B or better; or consent of instructor
Corequisites: There are no corequisites for this course.
Electromagnetic fundamentals, control of permittivity and permeability, dispersion, causality, double-negative materials, epsilon near-zero materials, transmission line-based metamaterials, composite right/left handed wave-guiding structures, even/odd mode analysis, differential signaling, electromagnetic bandgap structures, phase control, dual band devices, enhanced bandwidth devices, zeroth-order resonators, full wave simulation, device fabrication and laboratory measurement.

ECE 551 Digital Integrated Circuit Design 3R-3L-4C F
Prerequisites: ECE 250 Electronic Device Modeling 3R-3L-4C S,F, and ECE 233 Introduction to Digital Systems 3R-3L-4C F,W both with a grade of B or better; or graduate standing.
Corequisites: There are no corequisites for this course.
Design, performance analysis, and physical layout of CMOS logic. Custom and standard cell methodologies. Use of commercial CAD tools. Design issues such as interconnect, timing, and testing methods. Integral laboratory and project.

ECE 552 Analog Integrated Circuit Design 3R-3L-4C W
Prerequisites: ECE 351 Analog Electronics 3R-3L-4C F,W, and ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W Graduate standing; or with a grade of B or better in both courses; or consent of instructor
Corequisites: There are no corequisites for this course.
Design, performance analysis, and physical layout of analog integrated circuits. Focus on operational amplifier design and op-amp circuits. Introduction to mixed-signal circuit design such as switch-capacitors, A/D, or D/A systems. Integral laboratory and design project.

ECE 553 Radio-Frequency Integrated Circuit Design 3R-3L-4C S
Prerequisites: ECE 310 Communication Systems 3R-3L-4C F, S, and ECE 351 Analog Electronics 3R-3L-4C F,W Graduate standing (courses not required); or with a grade of B or better; or consent of instructor

Corequisites: There are no corequisites for this course.

Design, analysis, and physical layout of high-frequency analog integrated-circuits for modern RF transceivers. Circuit design for each primary transceiver component. General issues such as impedance matching and design of inductors on integrated circuits. Integral laboratory and design project.

ECE 554 Instrumentation 4R-0L-4C S
Prerequisites: ECE 351 Analog Electronics 3R-3L-4C F,W Graduate standing; or with grade of B or better; or consent of instructor

Corequisites: There are no corequisites for this course.


ECE 556 Power Electronics: DC Power Supplies 3R-3L-4C S
Prerequisites: ECE 351 Analog Electronics 3R-3L-4C F,W Graduate standing; or with grade of B or better; or consent of instructor

Corequisites: There are no corequisites for this course.

Analysis and design of AC-DC and DC-DC converters. Linear, basic switching, charge-pump, and fly-back topologies. Introduction to devices used in a power switching supplies. Thermal management. Integral laboratory.

ECE 557 Analog Test & Product Engineering 3R-3L-4C F
Prerequisites: ECE 300 Continuous-Time Signals & Systems 3R-3L-4C F,W,S, and ECE 351 Analog Electronics 3R-3L-4C F,W Graduate standing; or with a grade of B or better in both courses, or consent of instructor

Corequisites: There are no corequisites for this course.

Fundamental skills necessary to be an industrial integrated circuit test engineer or product engineer. Includes the economics associated with testing, impact of fabrication variation on devices, instrumentation associated with industrial testing, turning a data sheet into a test plan, industrial testing techniques for analog circuits, trade-offs between test time and test accuracy, statistical analysis of the data and statistical process control, the use of device interface boards necessary to control device loading for different tests. Integral labs with an industrial grade automatic tester (ATE).

ECE 558 Mixed-Signal Test & Product Engineering 3R-3L-4C W
Prerequisites: ECE 300 Continuous-Time Signals & Systems 3R-3L-4C F,W,S, and ECE 233 Introduction to Digital Systems 3R-3L-4C F,W, and ECE 351 Analog Electronics 3R-3L-4C F,W Graduate standing; or with grades of B or better in all three courses; or consent of instructor.

Corequisites: There are no corequisites for this course.

Industrial testing techniques for AC and DC tests of mixed-signal integrated circuits using an automatic test environment (ATE). Includes the structure and operation of comparators and standard data converters (DACs, ADCs), common data converter datasheet specifications, impact of data converter design on testing strategies,
statistical analysis of accuracy-time trade-offs. Integral labs using an industrial grade ATE.

**ECE 580 Digital Signal Processing 4R-0L-4C W**

**Prerequisites:** ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W, and MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S. *Graduate standing (courses not required); or with grade of B or better in both courses; or consent of instructor. MA367 with a grade of B or higher recommended.

**Corequisites:** There are no corequisites for this course.


**ECE 581 Digital Signal Processing Projects 2R-2L-2 or 4C**

**Prerequisites:** ECE 580 Digital Signal Processing 4R-0L-4C W concurrent registration

**Corequisites:** There are no corequisites for this course.

Computer-aided design of digital filters and other DSP modules. Software and hardware realization using modern DSP chips. DSP chip architectures, C-language programming, and interfacing techniques. Optional advanced project may be done to earn four credit hours; otherwise two credit hours are given. Integral laboratory.

**ECE 582 Advanced Image Processing 3R-3L-4C S**

**Prerequisites:** CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S Senior standing or Graduate standing

**Corequisites:** There are no corequisites for this course.


**ECE 584 Medical Imaging Systems 4R-0L-4C**

**Prerequisites:** ECE 300 Continuous-Time Signals & Systems 3R-3L-4C F,W,S Graduate standing; or with grade of B or better; or consent of instructor

**Corequisites:** There are no corequisites for this course.

Engineering principles of major imaging techniques/modalities for biomedical applications and health care including diagnostic x-ray, computed tomography, nuclear techniques, ultrasound, and magnetic resonance imaging. Topics include general characteristics of medical images; physical principles, signal processing to generate an image, and instrumentation of imaging modalities. Clinical applications of these technologies are also discussed. Same as BE541.

**ECE 596 Independent Study in Electrical Engineering 1C-4C**

**Prerequisites:** Consent of instructor

**Corequisites:** There are no corequisites for this course.

Special research or project based work that is done in consultation with a faculty member. Participation in these projects should require a graduate level of involvement and expectations, otherwise ECE498 Undergraduate Projects should be used. No more than 8 credit hours of ECE596 can be counted towards a graduate degree in the ECE Department without ECE Department Head Approval.

**ECE 597 Special Topics in Electrical Engineering 4C**
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Special topics courses of current interest to graduate students and senior undergraduates.

ECE 598 Thesis Research 1-4C
Prerequisites: Arranged
Corequisites: There are no corequisites for this course.
Thesis topic selected in consultation with adviser. Graduate students only.

ECE CPT Curricular Practical Training (CPT) 1R-0L-1C
Prerequisites: Consent of department head
Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complimentary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

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