ELECTRICAL AND COMPUTER ENGINEERING (E C E)

E C E 1 – COOPERATIVE EDUCATION PROGRAM
1 credit.

Work experience which combines classroom theory with practical knowledge of operations to provide students with a background upon which to base a professional career.
Requisites: Sophomore standing or member of Engineering Guest Students
Course Designation: Workplace - Workplace Experience Course
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025
Learning Outcomes: 1. Identify and respond appropriately to real-life engineering ethics cases relevant to co-op work
Audience: Undergraduate

2. Synthesize and apply appropriate technical education to real world technical work
Audience: Undergraduate

3. Communicate effectively in writing and speaking with a range of audiences in the workplace, including those without disciplinary expertise
Audience: Undergraduate

4. Develop professional and transferable habits like time management skills, collaborative problem-solving skills, and research skills for learning new information
Audience: Undergraduate

E C E 203 – SIGNALS, INFORMATION, AND COMPUTATION
3 credits.

Introduction to the signals, information, and computational techniques in electrical engineering.
Requisites: (MATH 211, 217, or 221) or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Manipulate complex numbers in the context of representing sinusoids
Audience: Undergraduate

2. Represent periodic continuous-time signals using the Fourier series
Audience: Undergraduate

3. Represent finite-duration discrete-time signals using the discrete Fourier transform
Audience: Undergraduate

4. Determine sampling parameters for analog-to-digital conversion of signals
Audience: Undergraduate

5. Apply digital filters to discrete-time signals
Audience: Undergraduate

6. Write code using numerical computing software to manipulate signals
Audience: Undergraduate

E C E 204 – DATA SCIENCE & ENGINEERING
3 credits.

A hands-on introduction to Data Science using the Python programming language. Data-centric and computational thinking. Describe, analyze, and make predictions using data from real-world phenomena. Programming in Python. Importing, manipulating, summarizing, and visualizing data of various types. Notions of bias, fairness, and ethics in data science.
Requisites: MATH 112, 114, 171, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Write working code in Python to import, manipulate, analyze, visualize, and otherwise interact with datasets of various types.
Audience: Undergraduate

2. Perform descriptive analyses to extract, summarize, and interpret salient features from datasets.
Audience: Undergraduate

3. Perform predictive analyses to model trends and make predictions from datasets.
Audience: Undergraduate

4. Apply techniques to identify and clean data that contains missing entries, outliers, or other forms of noise or uncertainty.
Audience: Undergraduate

5. Recognize and evaluate potential issues pertaining to bias, fairness, privacy, and ethics in applying data science techniques.
Audience: Undergraduate

E C E 210 – INTRODUCTORY EXPERIENCE IN ELECTRICAL ENGINEERING
2 credits.

An introduction to electrical and electronic devices, circuits and systems including software and hardware focusing on a real-world project.
Requisites: None
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Create and read electrical circuit schematics and systematically assemble them on a breadboard using discrete components

Audience: Undergraduate

2. Verify operation of electrical circuits using electrical measuring instruments such as multimeters and oscilloscopes
Audience: Undergraduate

3. Use a microcontroller with computer coding to read digital/analog signals, and provide digital/analog outputs that perform simple electrical functions
Audience: Undergraduate

4. Communicate test results from electrical measurements using tables and charts
Audience: Undergraduate

5. Perform simple electrical circuit calculations on quantities such as power, energy, voltage, current, frequency and time
Audience: Undergraduate

E C E 219 – ANALYTICAL METHODS FOR ELECTROMAGNETICS ENGINEERING
2 credits.

Reviews basic calculations in electromagnetic engineering upon which all higher level concepts and physical model construction are based. It emphasizes quantitative calculation mastery in three spatial dimensions. Applies analysis tools from vector calculus to the calculation and prediction of electrical system properties. Examples include calculating electric and magnetic fields, electric potentials, total electric charge, and electric flux from change or current sources.
Requisites: MATH 234 or 376, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2023
Learning Outcomes: 1. Describe infinitesimal increments (length, area, volume) using cartesian, cylindrical, and spherical coordinates
Audience: Undergraduate

2. Compute partial derivatives, gradient, divergence, and curl using cartesian, cylindrical, and spherical coordinates, applied to basic electrostatics and magnetostatics problems
Audience: Undergraduate

3. Compute flux integrals, line integrals, and circulation using cartesian, cylindrical, and spherical coordinates, applied to basic electrostatics and magnetostatics problems
Audience: Undergraduate

4. Calculate total electric charge from specified charge distributions
Audience: Undergraduate

5. Calculate electric fields from specified charge distributions (Coulomb's Law)
Audience: Undergraduate

6. Calculate electric fields from electrostatic potentials
Audience: Undergraduate

7. Calculate electrostatic potentials from electric fields
Audience: Undergraduate

E C E 220 – ELECTRODYNAMICS I
3 credits.

Potential theory; static and dynamic electric and magnetic fields; macroscopic theory of dielectric and magnetic materials; Maxwell's equations; boundary conditions; wave equation; introduction to transmission lines.
Requisites: (PHYSICS 202, 208, or 248) and E C E 219, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2024
Learning Outcomes: 1. Calculate static electric and magnetic fields from charge and current distributions
Audience: Undergraduate

2. Use concepts of electric and magnetic fields to calculate forces, work, and energy
Audience: Undergraduate

3. Develop expressions for macroscopic electric circuit lumped parameters such as inductance and capacitance by applying principles of electric and magnetic fields
Audience: Undergraduate

4. Use boundary conditions on electric and magnetic fields to compute field changes at material discontinuities
Audience: Undergraduate

5. Apply bounce diagrams to calculate time and space distribution of currents and voltages on transmission lines
Audience: Undergraduate

E C E 222 – ELECTRODYNAMICS I
4 credits.

Vector calculus application to electrodynamics problems; potential theory; static and dynamic electric and magnetic fields; macroscopic theory of dielectric and magnetic materials; Maxwell's equations; boundary conditions; wave equation; introduction to transmission lines.
Requisites: (PHYSICS 202, 208, or 248) and (MATH 234 or 376) or member of Engineering Guest Students. Not open to students with credit in E C E 220.
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Apply concepts from single-variable and vector calculus to solve electrodynamics problems
Audience: Undergraduate

2. Calculate static electric and magnetic fields from charge and current distributions
Audience: Undergraduate

3. Use concepts of electric and magnetic fields to calculate forces, work, and energy
Audience: Undergraduate

4. Use boundary conditions on electric and magnetic fields to compute field changes at interfaces between materials
Audience: Undergraduate

5. Develop expressions for macroscopic electric circuit lumped parameters such as inductance and capacitance by applying principles of electric and magnetic fields
Audience: Undergraduate

6. Apply bounce diagrams to calculate time and space distribution of currents and voltages on transmission lines
Audience: Undergraduate

E C E 230 – CIRCUIT ANALYSIS
4 credits.

Ohm's law, Kirchhoff's laws, resistive circuits, nodal and mesh analysis, superposition, equivalent circuits using Thevenin-Norton theories, op amps and op amp circuits, first-order circuits, second-order circuits, sinusoidal steady state, phasors, RMS value, complex power, power factor, mutual inductance, linear and ideal transformers, ideal filters and transfer functions.
Requisites: MATH 222 and (PHYSICS 202, 208, or 248), or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Solve DC electric circuits composed of resistors, voltage and current sources using Kirchhoff's laws, employing node-voltage and mesh-current analysis along with Thevenin and Norton equivalent circuits
Audience: Undergraduate

2. Analyze circuits employing op amps
Audience: Undergraduate

3. Formulate transient response of first-order and second-order electric circuits incorporating resistors, inductors, capacitors and sources that are switched
Audience: Undergraduate

4. Determine AC steady-state response of electric circuits utilizing phasors and calculation with complex numbers
Audience: Undergraduate

5. Characterize the complex power transferred to and from electric circuits
Audience: Undergraduate

6. Conduct AC analysis of circuits with transformers
Audience: Undergraduate

E C E/PHYSICS 235 – INTRODUCTION TO SOLID STATE ELECTRONICS
3 credits.

An introduction to the physical principles underlying solid-state electronic and photonic devices, including elements of quantum mechanics, crystal structure, semiconductor band theory, carrier statistics, and band diagrams. Offers examples of modern semiconductor structures. Prior experience with MATLAB [such as E C E 203] is strongly encouraged but not required.
Requisites: MATH 222 and (PHYSICS 202, 208, or 248), or member of Engineering Guest Students
Course Designation: Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

E C E/COMP SCI 252 — INTRODUCTION TO COMPUTER ENGINEERING
3 credits.

Logic components built with transistors, rudimentary Boolean algebra, basic combinational logic design, basic synchronous sequential logic design, basic computer organization and design, introductory machine- and assembly-language programming.
Requisites: None
Course Designation: Level - Elementary
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Perform basic operations on binary representations for data
Audience: Undergraduate

2. Analyze simple combinational and sequential digital logic and memory systems
Audience: Undergraduate

3. Identify the components and operation of an instruction set processor and write programs using assembly language
Audience: Undergraduate

4. Recognize and analyze ethical and professional responsibilities in engineering contexts
Audience: Undergraduate

E C E 270 — CIRCUITS LABORATORY I
1 credit.

Experiments cover Kirchhoff's laws, inductors, basic operational amplifier circuits, and frequency response.
Requisites: E C E 210 and (E C E 230 or concurrent enrollment), or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Compare physical electronic circuit functionality to simulated functionality using computer models
Audience: Undergraduate

2. Create and read electronic circuit schematics and systematically assemble them on a breadboard using discrete components
Audience: Undergraduate

3. Identify electronic components using electronic instruments such as multi-meters, signal generators and oscilloscopes
Audience: Undergraduate

4. Operate electronic circuits with electrical sources such as power supplies and signal generators
Audience: Undergraduate

5. Verify operation of electrical circuits using electronic measuring instruments such as multi-meters and oscilloscopes
Audience: Undergraduate

6. Perform simple electronic circuit calculations on quantities such as voltage, current, power, frequency and time
Audience: Undergraduate

7. Communicate test results from electrical measurements using tables, equations and charts
Audience: Undergraduate

E C E 271 – CIRCUITS LABORATORY II
1 credit.

Experiments cover electronic device characteristics, limitations and applications of operational amplifiers, and feedback circuits.
Requisites: E C E 270 and (E C E 340 or concurrent enrollment), or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Predict electronic circuit outcomes using equations and simulations
Audience: Undergraduate

2. Compare physical electronic circuit functionality to predicted functionality using computer models
Audience: Undergraduate

3. Specify analog circuits to perform linear signal processing with passive and active components such as resistors, capacitors, inductors, transistors and op-amps
Audience: Undergraduate

4. Specify analog circuits to perform non-linear signal processing with passive and active components such as diodes, transistors and op-amps
Audience: Undergraduate

5. Construct circuits to implement linear signal processing such as gain
Audience: Undergraduate

6. Construct circuits to implement non-linear signal processing such as converting AC to DC and boosting DC voltages
Audience: Undergraduate

7. Communicate test results from electrical measurements using tables, equations and charts
Audience: Undergraduate

E C E 303 – INTRODUCTION TO REAL-TIME DIGITAL SIGNAL PROCESSING
2 credits.

Emphasizes the implementation of DSP algorithms on a digital signal processor in "real-time." Many of the signal processing algorithms that were used in E C E 203 will be reviewed in MATLAB and then will be implemented on a floating point signal processor in "real-time" using the C programming language. Explore many basic digital signal processing processes in real-time. Gain the ability to create and develop your own Digital Signal Processing projects for a modern digital signal precessor using an Integrated Development Environment. Lab hardware will be provided.
Requisites: E C E 203 or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Define what it means for a system to be real-time
Audience: Undergraduate

2. Implement a real-time signal processing platform for real-time system evaluation
Audience: Undergraduate

3. Operate a signal processing system to evaluate real-time software performance
Audience: Undergraduate

4. Analyze the performance of real-time software
Audience: Undergraduate

5. Optimize the software performance of a real-time system
Audience: Undergraduate

6. Verify the software performance of a real-time system
Audience: Undergraduate

7. Communicate results from real-time systems using tables, equations and graphs
Audience: Undergraduate

E C E 304 – ELECTRIC MACHINES LABORATORY
1 credit.

Terminal characteristics of electric machines, elements of speed control, voltage regulation, and applications in systems. Emphasis on the experimental approach to the solution of complex physical problems.
Requisites: (E C E 355, 356, or concurrent enrollment) or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Describe the performance characteristics of electric machines, including dc, induction, and synchronous machines
Audience: Undergraduate

2. Use laboratory instrumentation and techniques to take accurate measurements of the performance characteristics of ac machines and their drives
Audience: Undergraduate

3. Prepare high-quality lab reports that accurately and clearly present the results of the experimental tests with explanations of the rationale for the test results, including discussion of discrepancies
Audience: Undergraduate

4. Follow laboratory safety procedures for safely working with ac machines and drives when making experimental measurements
Audience: Undergraduate

E C E 305 – SEMICONDUCTOR PROPERTIES LABORATORY
1 credit.

Introduction to some fundamental properties of semiconductor materials and devices through the use of characterization techniques common in modern electronic industry. These concepts include: charge carriers; energy bands; space charge regions; carrier drift, diffusion and recombination; light emission; and lattice vibrations.
Requisites: E C E 271 and (E C E 335 or concurrent enrollment), or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Describe the relationship between semiconductor material properties and semiconductor device properties, such as mobility, capacitance, and spontaneous/stimulated light emission
Audience: Undergraduate

2. Perform electrical and optical characterization measurements using laboratory instruments
Audience: Undergraduate

3. Write technical reports based on experimental results
Audience: Undergraduate

E C E 313 – OPTOELECTRONICS LAB
1 credit.

Light detection using photovoltaic and photoconductive detectors and phototransistors. Light generation using light emitting diodes and laser diodes. Light transmission using optical fibers. Optoisolators and optical switches. Light emitting diode and liquid crystal displays.
Requisites: E C E 271 and 340, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Describe the relationship between the light emission/detection properties of semiconductors, and the operation of optoelectronic devices, such as light emitting diodes (LEDs), lasers and optical fibers
Audience: Undergraduate

2. Perform optical characterization measurements using laboratory instruments
Audience: Undergraduate

3. Write technical reports based on experimental results
Audience: Undergraduate

E C E 315 – INTRODUCTORY MICROPROCESSOR LABORATORY
1 credit.

Software and hardware experiments with a microcomputer system. Assembly language programming, simple input/output interfacing, and interrupt processing in microcomputer systems.
Requisites: E C E 353 or concurrent enrollment, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Develop a schematic design using CAD tools for an embedded system
Audience: Undergraduate

2. Design a printed circuit board (PCB) for an embedded system using CAD tools
Audience: Undergraduate

3. Assemble an embedded system on a printed circuit board (PCB)
Audience: Undergraduate

4. Write firmware used to control an embedded system
Audience: Undergraduate

E C E 317 – SENSORS LABORATORY
1 credit.

A hands-on introduction to a variety of different sensor types. Labs incorporate implementation concerns involving interference, isolation, linearity, amplification, and grounding.
Requisites: E C E 271 and (E C E 340 or concurrent enrollment), or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Predict electronic circuit outcomes using equations and simulations
Audience: Undergraduate

2. Compare physical electronic circuit functionality to predicted functionality
Audience: Undergraduate

3. Specify the analog signal processing required to generate usable sensor signals
Audience: Undergraduate

4. Design electronic circuits with the necessary signal processing to convert sensor signals to usable electronic signals
Audience: Undergraduate

5. Construct electronic circuits to process sensors signals
Audience: Undergraduate

6. Verify operation of sensor signal processing circuits using electronic measuring instruments such as multi-meters, oscilloscopes and spectrum analyzers
Audience: Undergraduate

7. Communicate test results from electrical measurements using tables, equations and graphs
Audience: Undergraduate

E C E 320 – ELECTRODYNAMICS II
3 credits.

Static and dynamic electromagnetic fields; forces and work in electromechanical systems; magnetic circuits; plane wave propagation; reflection of plane waves; generalized transmission line equations; current and voltage on transmission lines; impedance transformation and matching; Smith charts.
Requisites: E C E 220, 222, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Apply Faraday's law to calculate emf induced by time changing magnetic fields
Audience: Undergraduate

2. Use Maxwell's equations to develop the wave equation for electromagnetic fields
Audience: Undergraduate

3. Calculate propagation of plane waves in various media and reflection and refraction at media discontinuities
Audience: Undergraduate

4. Compute voltages and currents on transmission lines under time harmonic excitation
Audience: Undergraduate

5. Use matching techniques to eliminate reflections from mismatched loads on transmission lines
Audience: Undergraduate

E C E 330 – SIGNALS AND SYSTEMS
3 credits.

Time-domain response and convolution; frequency-domain response using Fourier series, Fourier transform, Laplace transform; discrete Fourier series and transform; sampling; z-transform; relationships between time and frequency descriptions of discrete and continuous signals and systems.
Requisites: E C E 203 or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Determine whether a system is linear, time-invariant, stable, and/or causal
Audience: Undergraduate

2. Convert between time-domain and frequency-domain representations of signals
Audience: Undergraduate

3. Analyze the behavior of continuous-time and discrete-time systems using time-domain and frequency-domain techniques
Audience: Undergraduate

4. Compute and evaluate single-input single-output transfer functions from differential and difference equations
Audience: Undergraduate

5. Perform discrete-time processing of continuous-time signals using sampling, filtering, and reconstruction
Audience: Undergraduate

E C E 331 – INTRODUCTION TO RANDOM SIGNAL ANALYSIS AND STATISTICS
3 credits.

Introduction to probability, random variables, and random processes. Confidence intervals, introduction to experimental design and hypothesis testing. Statistical averages, correlation, and spectral analysis for wide sense stationary processes. Random signals and noise in linear systems.
Requisites: (E C E 203 or 330) or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Demonstrate a working knowledge of the basic axioms and identities of probability theory
Audience: Undergraduate

2. Determine probability distributions for different random variables
Audience: Undergraduate

3. Apply properties of expectation and variance to functions of random variables
Audience: Undergraduate

4. Apply basic statistical methods for parameter estimation
Audience: Undergraduate

5. Apply the methods of probability to everyday problems
Audience: Undergraduate

E C E 332 – FEEDBACK CONTROL SYSTEMS
3 credits.

Modeling of continuous systems; computer-aided solutions to systems problems; feedback control systems; stability, frequency response and transient response using root locus, frequency domain and state variable methods.
Requisites: E C E 330 or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Apply Laplace Transforms to problems in control
Audience: Undergraduate

2. Employ symbolic computations and apply numerical methods to the simulation and analysis of control systems
Audience: Undergraduate

3. Design control systems using frequency response methods and Bode Diagrams
Audience: Undergraduate

4. Formulate and manipulate signal flow graphs and block diagrams to characterize systems
Audience: Undergraduate

5. Evaluate stability of systems
Audience: Undergraduate

E C E 334 – STATE SPACE SYSTEMS ANALYSIS
3 credits.

Analysis of systems using matrix methods to write and solve state-variable differential equations. Additional topics include stability, controllability, observability, state feedback, observers, and dynamic output feedback.
Requisites: E C E 330, MATH 319, 320, 376, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Formulate state-space models of engineering systems
Audience: Undergraduate

2. Understand solutions of ordinary differential equations (ODE) and visualize them using vector fields and phase portraits
Audience: Undergraduate

3. Linearize nonlinear state-space models and understand the limitations of linear systems analysis
Audience: Undergraduate

4. Solve a system of linear differential equations using matrix exponentials, diagonalizations, and Jordan normal forms
Audience: Undergraduate

5. Systematically analyze linear state-space systems using matrix methods

Audience: Undergraduate

6. Understand and fluently use concepts such as: time-invariance, stability, controllability, and observability
Audience: Undergraduate

7. Design linear state-feedback controllers and observers
Audience: Undergraduate

E C E 335 – MICROELECTRONIC DEVICES
3 credits.

Characteristics of semiconductors; study of physical mechanisms and circuit modeling of solid state electronic and photonic devices; principles of microelectronic processing and examples of integrated circuits.
Requisites: (E C E 220 or 222), E C E 230, and PHYSICS/E C E 235, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Explain the physical operation of microelectronic devices, such as diodes, bipolar junction transistors, and field-effect transistors
Audience: Undergraduate

2. Identify design tradeoffs for electronic devices
Audience: Undergraduate

3. Identify, evaluate and explain basic microelectronic processing techniques for device fabrication
Audience: Undergraduate

4. Summarize basic semiconductor materials and their properties and implement them to examine new and emerging materials
Audience: Undergraduate

E C E 340 – ELECTRONIC CIRCUITS I
3 credits.

A first course in modeling, characterization, and application of semiconductor devices and integrated circuits. Development of appropriate models for circuit-level behavior of diodes, bi-polar and field effect transistors, and non-ideal op-amps. Application in analysis and design of linear amplifiers. Frequency domain characterization of transistor circuits.
Requisites: (E C E 203 and 230) or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Analyze functions and DC and AC operations of diodes, metal-oxide-semiconductor field transistors, and bipolar junction transistors
Audience: Undergraduate

2. Utilize large and small signal models of diodes, metal-oxide-semiconductor field transistors and bipolar junction transistors in analysis of analog circuits
Audience: Undergraduate

3. Analyze and design single stage analog amplifiers
Audience: Undergraduate

4. Analyze and design basic differential amplifiers and multistage amplifiers
Audience: Undergraduate

5. Analyze basic operational amplifier circuits
Audience: Undergraduate

E C E 342 – ELECTRONIC CIRCUITS II
3 credits.

A second course in modeling and application of semiconductor devices and integrated circuits. Advanced transistor amplifier analysis, including feedback effects. Design for power amplifiers, op-amps, analog filters, oscillators, A/D and D/A converters, and power converters. Introduction to transistor level design of CMOS digital circuits.
Requisites: E C E 340 or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Identify the topologies of feedback amplifiers
Audience: Undergraduate

2. Describe the uses of different feedback amplifier topologies
Audience: Undergraduate

3. Describe the input and output impedances associated with each topology
Audience: Undergraduate

4. Calculate the gain and input and output impedances of feedback amplifiers
Audience: Undergraduate

5. Design feedback amplifiers for specific applications
Audience: Undergraduate

6. Calculate frequency response and stability of feedback amplifiers
Audience: Undergraduate

E C E/COMP SCI 352 – DIGITAL SYSTEM FUNDAMENTALS
3 credits.

Logic components, Boolean algebra, combinational logic analysis and synthesis, synchronous and asynchronous sequential logic analysis and design, digital subsystems, computer organization and design.
Requisites: Satisfied Quantitative Reasoning (QR) A requirement and E C E/COMP SCI 252
Course Designation: Gen Ed - Quantitative Reasoning Part B
Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

E C E 353 – INTRODUCTION TO MICROPROCESSOR SYSTEMS
3 credits.

Introduction to architecture, operation, and application of microprocessors; microprocessor programming; address decoding; system timing; parallel, serial, and analog I/O; interrupts and direct memory access; interfacing to static and dynamic RAM; microcontrollers.
Requisites: E C E/COMP SCI 252 and (COMP SCI 300 or 302 prior to Fall 2018), or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Program a microcontroller to meet functional requirements of an embedded system
Audience: Undergraduate

2. Write, debug, and optimize programs for an efficient embedded system
Audience: Undergraduate

3. Interface a microcontroller to various on-chip and off-chip peripherals
Audience: Undergraduate

4. Design and implement a microcontroller-based embedded system
Audience: Undergraduate

5. Interpret technical documents related to embedded system components
Audience: Undergraduate

E C E/COMP SCI 354 – MACHINE ORGANIZATION AND PROGRAMMING
3 credits.

An introduction to fundamental structures of computer systems and the C programming language with a focus on the low-level interrelationships and impacts on performance. Topics include the virtual address space and virtual memory, the heap and dynamic memory management, the memory hierarchy and caching, assembly language and the stack, communication and interrupts/signals, compiling and assemblers/linkers.
Requisites: E C E/COMP SCI 252 and (COMP SCI 300 or 302) or graduate/professional standing or declared in the Capstone Certificate in Computer Sciences for Professionals
Course Designation: Gen Ed - Quantitative Reasoning Part B
Breadth - Natural Science
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

E C E 355 – ELECTROMECHANICAL ENERGY CONVERSION
3 credits.

Energy storage and conversion, force and emf production, coupled circuit analysis of systems with both electrical and mechanical inputs. Applications to electric motors and generators and other electromechanical transducers.
Requisites: E C E 230 or 376, graduate/professional standing, member of Engineering Guest Students, or declared in Capstone Certificate in Power Conversion and Control
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Apply the theory underlying energy conversion between electrical and mechanical systems
Audience: Undergraduate

2. Apply analysis techniques for analyzing electric power flow for single and three phase systems including the effects of harmonics
Audience: Undergraduate

3. Apply knowledge of magnetics concepts for use in transformers, actuators and electromechanical energy conversion devices
Audience: Undergraduate

4. Explain fundamental understanding of Lorentz force machines including dc, induction and synchronous types
Audience: Undergraduate

5. Define and specify power converters and supply systems for application circuits and systems
Audience: Undergraduate

6. Identify operational and design features of electric utility power systems
Audience: Undergraduate

E C E 356 – ELECTRIC POWER PROCESSING FOR ALTERNATIVE ENERGY SYSTEMS
3 credits.

Introduction to electrical power processing technologies that are necessary to convert energy from alternative sources into useful electrical forms. Several specific alternative energy sources are examined, providing platforms for introducing basic concepts in power electronics, electric machines, and adjustable-speed drives.
Requisites: (E C E 230 or 376) or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2021
Learning Outcomes: 1. Analyze and design small-scale solar electric systems
Audience: Undergraduate

2. Analyze and design small-scale wind turbine electric systems
Audience: Undergraduate

3. Analyze and design small-scale electric energy storage systems
Audience: Undergraduate

4. Analyze simple electric transportation drivetrains
Audience: Undergraduate

5. Analyze sustainability practices in electrical energy systems
Audience: Undergraduate

E C E 370 – ADVANCED LABORATORY
2 credits.

Experiments related to the required core material.
Requisites: E C E 271 and (E C E 340 or concurrent enrollment), or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Predict electronic circuit outcomes using equations and simulations
Audience: Undergraduate

2. Build functional electronic sub-systems
Audience: Undergraduate

3. Compare electronic circuit functionality to predicted functionality
Audience: Undergraduate

4. Debug non-functional electronic sub-systems using prediction and measurement tools
Audience: Undergraduate

5. Repair non-functional electronic sub-systems using hardware corrective techniques
Audience: Undergraduate

6. Combine electronic sub-systems into an electronic control system
Audience: Undergraduate

7. Verify electronic system performance utilizing multi-meters, signal generators, and oscilloscopes
Audience: Undergraduate

E C E 376 — ELECTRICAL AND ELECTRONIC CIRCUITS
3 credits.

Ohm's law, Kirchhoff's laws, resistive circuits, nodal and mesh analysis, superposition, equivalent circuits using Thevenin and Norton Theorems, op amps and op amp circuits, capacitors and inductors in first-order circuits, sinusoidal steady state, phasors, RMS value, complex power, power factor, mutual inductance, linear and ideal transformers.
Requisites: MATH 222 and (PHYSICS 202, 208, or 248), or member of Engineering Guest Students. Not open to students with credit for E C E 230.
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Solve DC electric circuits composed of resistors, voltage and current sources
Audience: Undergraduate

2. Analyze electrical behavior of circuits containing inductors, capacitors and transformers
Audience: Undergraduate

3. Formulate transient response of electric circuits incorporating resistors, inductors, capacitors and sources that are switched
Audience: Undergraduate

4. Determine AC steady-state response of electric circuits utilizing phasors and calculation with complex numbers
Audience: Undergraduate

5. Characterize the complex power transferred to and from electric circuits
Audience: Undergraduate

E C E 377 — FUNDAMENTALS OF ELECTRICAL AND ELECTRO-MECHANICAL POWER CONVERSION
3 credits.

Fundamentals of electromagnetic induction and application to transformers and induction heating; Lorentz forces with a focus on the operation and control of DC and AC motors and linear actuators; electrical power conversion using power electronics for motor drives and direct power converters.
Requisites: (MATH 234 or 376), (PHYSICS 202, 208, or 248), and E C E 376, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Formulate theory underlying energy conversion between electrical and mechanical systems
Audience: Undergraduate

2. Determine physical laws for electromagnetic actuators and motors
Audience: Undergraduate

3. Utilize magnetic concepts including magnetic equivalent circuit analysis to model transformers, actuators and electromechanical energy conversion devices
Audience: Undergraduate

4. Evaluate power electronics circuits used for actuators, motors and power supplies
Audience: Undergraduate

E C E 379 — SPECIAL TOPICS IN ELECTRICAL AND COMPUTER ENGINEERING
1-4 credits.

Topics of special interest to undergrads in electrical and computer engineering.
Requisites: Sophomore standing or member of Engineering Guest Students
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2022

E C E 399 — INDEPENDENT STUDY
1-3 credits.

Directed study projects as arranged with instructor.
Requisites: Consent of instructor
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

E C E 401 – ELECTRO-ACOUSTICAL ENGINEERING
3 credits.

Principles of plane and spherical sound waves; acoustical, mechanical, and electrical analogies; electroacoustic transducer materials and techniques; specific types of transducers such as microphones and loudspeakers.
Requisites: E C E 203, graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2024
Learning Outcomes: 1. Describe the generation and propagation of plane and spherical sound waves
Audience: Undergraduate

2. Analyze acoustic wave transmission and reflection at flat boundaries of different media
Audience: Undergraduate

3. Describe working principles of different types of transducers such as microphones and loudspeakers
Audience: Undergraduate

4. Use computer-based tools to process acoustic signals
Audience: Undergraduate

5. Describe the working mechanism of acoustic beamforming
Audience: Undergraduate

E C E 411 – INTRODUCTION TO ELECTRIC DRIVE SYSTEMS
3 credits.

Basic concepts of electric drive systems. Emphasis on system analysis and application. Topics include: dc machine control, variable frequency operation of induction and synchronous machines, unbalanced operation, scaling laws, adjustable speed drives, adjustable torque drives, coupled circuit modeling of ac machines.
Requisites: (E C E 355, 356, or 377), graduate/professional standing, or member of Engineering Guest Students, or declared in Power Conversion and Control Capstone Certificate
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Predict the steady-state torque, speed, voltage, current, and power relationships of DC, AC-induction and AC-synchronous (including permanent magnet) electric motors and generators for constant-speed and adjustable-speed operation given equivalent circuit parameters.
Audience: Both Grad & Undergrad

2. Identify the impact of second order effects such as temperature, armature reaction magnetic fields, and magnetic circuit saturation on the predicted steady state performance of electric motors and generators for constant-speed and adjustable speed operation.
Audience: Both Grad & Undergrad

3. Determine the power electronics circuit layout for power conversion circuits that are used to adjust input voltage and/or frequency for adjustable-speed electric motor and generator systems.
Audience: Both Grad & Undergrad

4. Describe the basic concepts of torque and speed control of DC and AC electric motors including field-oriented control of AC induction and synchronous motors.
Audience: Both Grad & Undergrad

5. Predict the steady state behavior of a motor drive system composed of a machine, drive and basic control.
Audience: Graduate

E C E 412 – POWER ELECTRONIC CIRCUITS
3 credits.

Operating characteristics of power semiconductor devices such as Bipolar Junction Transistors, IGBTs, MOSFETs and Thyristors. Fundamentals of power converter circuits including dc/dc converters, phase controlled ac/dc rectifiers and dc/ac inverters. Practical issues in the design and operation of converters.
Requisites: E C E 342, graduate/professional standing, member of Engineering Guest Students, or declared in Capstone Certificate in Power Conversion and Control
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Analyze, derive operating principles, and sketch transient voltage and current waveforms for common power electronic circuits (dc-dc, dc-ac, and ac-dc converters)
Audience: Both Grad & Undergrad

2. Dimension and select key components in power electronic circuits in order to meet a design specification
Audience: Both Grad & Undergrad

3. Analyze the performance and conduct basic design steps for closed loop regulation of power electronic circuits
Audience: Both Grad & Undergrad

4. Communicate how power conversion technology is utilized in real-world applications
Audience: Graduate

E C E 420 – ELECTROMAGNETIC WAVE TRANSMISSION
3 credits.

Transmission lines: frequency domain analysis of radio frequency and microwave transmission circuits including power relations and graphical and computer methods. Electromagnetic waves: planar optical components, pulse dispersion, phase front considerations for optical components, conducting waveguides, dielectric waveguides. Radiation: retarded potentials, elemental dipoles, radiating antenna characterization, receiving mode.
Requisites: E C E 320, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2024
Learning Outcomes: 1. Compute transmission line voltages, currents, impedances, and reflection coefficients in transient and harmonic circuits
Audience: Both Grad & Undergrad

2. Design matching networks utilizing a Smith chart
Audience: Both Grad & Undergrad

3. Compute reflection and transmission of plane waves at an interface
Audience: Both Grad & Undergrad

4. Use the Friis transmission equation for link budget analysis in antenna communication systems
Audience: Both Grad & Undergrad

5. Analyze TM and TE modes of circular and rectangular waveguides
Audience: Graduate

E C E 427 – ELECTRIC POWER SYSTEMS
3 credits.

The electric power industry, operation of power systems, load flow, fault calculations, economic dispatch, general technical problems of electric power networks.
Requisites: E C E 330, graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Calculate basic quantities in three-phase power systems, including instantaneous, active and reactive power
Audience: Undergraduate

2. Construct and solve the power flow equations for steady-state operation of power systems using single-phase equivalent systems and per unit analysis
Audience: Undergraduate

3. Use the method of symmetric components to analyze fault conditions
Audience: Undergraduate

4. With a team, complete a power system design project on sustainable energy systems and effectively communicate the results
Audience: Undergraduate

5. Analyze the causes of and solutions for the sustainability challenge of affordable and clean energy
Audience: Undergraduate

6. Analyze sustainability issues and/or practices using a systems-based approach
Audience: Undergraduate

E C E 431 – DIGITAL SIGNAL PROCESSING
3 credits.

Sampling continuous-time signals and reconstruction of continuous-time signals from samples; spectral analysis of signals using the discrete Fourier transform; the fast Fourier transform and fast convolution methods; z-transforms; finite and infinite impulse response filter design techniques; signal flow graphs and introduction to filter implementation.
Requisites: E C E 330, graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Choose filter characteristics and parameters for sampling and interpolating signals
Audience: Undergraduate

2. Relate pole and zero locations to system properties
Audience: Undergraduate

3. Design discrete-time filters
Audience: Undergraduate

4. Perform spectral analysis of signals
Audience: Undergraduate

5. Perform signal processing operations using an engineering software package
Audience: Undergraduate

E C E 432 – DIGITAL SIGNAL PROCESSING LABORATORY
3 credits.

Implementation of digital signal processing algorithms on special-purpose and general-purpose hardware. Use of assembly and high-level languages, and simulator to develop and test IIR, FIR filters and the FFT for modern DSP chips. Scaling for fixed point arithmetic. Use of high level languages to implement real time, object oriented component based DSP systems in general purpose computers. DSP applications, including data and voice communication systems.
Requisites: E C E 330 and COMP SCI 300, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2023
Learning Outcomes: 1. Take specifications for a signal processing system and select an appropriate type of digital filter meeting required behavior
Audience: Both Grad & Undergrad

2. Apply discrete-time linear-system theory to design a filter
Audience: Both Grad & Undergrad

3. Code the filter in an algorithmic computer programming language using paradigms that allow embedding in a large software system
Audience: Both Grad & Undergrad

4. Apply the theory of time-domain and Fourier-domain representations of signals and linear systems operating on those signals to interpret and verify the behavior of the coded filter
Audience: Both Grad & Undergrad

5. Effectively communicate these steps in written documents
Audience: Both Grad & Undergrad

6. Quantify the relative performance of digital filters in different computing environments
Audience: Graduate

E C E 434 – PHOTONICS
3 credits.

Introduction to ray optics, physical optics and interference, applications of Fourier optics, absorption, dispersion, and polarization of light. Light sources, including lasers (gas, solid state, and semiconductor), modulation and detection of light.
Requisites: PHYSICS/E C E 235 and (E C E 320, PHYSICS 322, or concurrent enrollment in either one), graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Apply Maxwell's equations to explain optical propagation, loss, and gain in free space, dielectrics, semiconductors, and metals
Audience: Both Grad & Undergrad

2. Calculate reflectance and transmittance of light at interfaces under a variety of conditions
Audience: Both Grad & Undergrad

3. Explain the principles of interference and the functionality of interferometers and spectrometers
Audience: Both Grad & Undergrad

4. Explain the differences between various light sources, including different types of lasers
Audience: Both Grad & Undergrad

5. Calculate the behavior of rays using ray matrices, especially for imaging
Audience: Both Grad & Undergrad

6. Review and assess current literature in the field of photonics
Audience: Graduate

E C E/COMP SCI/MATH 435 – INTRODUCTION TO CRYPTOGRAPHY
3 credits.

Cryptography is the art and science of transmitting digital information in a secure manner. Provides an introduction to its technical aspects.
Requisites: (MATH 320, 340, 341, or 375) or graduate/professional standing or member of the Pre-Masters Mathematics (Visiting International) Program
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

E C E 436 – COMMUNICATION SYSTEMS I
3 credits.

Amplitude, frequency, pulse, and pulse-code modulation. Narrow-band noise representation and signal-to-noise ratios for various modulation schemes. Pulse shaping, timing recovery, carrier synchronization, and equalization. Sampling, quantization and coding.
Requisites: (E C E 203 or 330), graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Characterize the energy and power of signals occurring in analog communication systems using the theory of inner products and properties of the Fourier series and the Fourier transform
Audience: Undergraduate

2. Apply the theory of the narrowband representation of signals to the modulation and recovery of signals using the linear analog modulation techniques
Audience: Undergraduate

3. Design phase and frequency modulation systems based on parameters of non-linear modulation
Audience: Undergraduate

4. Apply random process theory to characterize the behavior of analog modulation systems in the presence of interference
Audience: Undergraduate

5. Implement analog communication systems in discrete-time (software-defined radio)
Audience: Undergraduate

6. Design and conduct experiments to confirm the performance of analog modulation systems in the presence of interfering noise
Audience: Undergraduate

E C E 437 – COMMUNICATION SYSTEMS II
3 credits.

Statistical analysis of information transmission systems. Probability of error, design of receivers for digital transmission through additive white Gaussian noise channels and bandlimited channels. Spread spectrum communication systems. Channel capacity, source and error control coding.
Requisites: (E C E 203 or 330), graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Formulate baseband and carrier-modulated waveforms for digital communication including PAM, PSK, QAM and OFDM
Audience: Undergraduate

2. Apply inner product space concepts and the theory of optimal receivers to map waveforms to signal constellations
Audience: Undergraduate

3. Determine performance resulting from sub-optimal receivers
Audience: Undergraduate

4. Calculate exact and upper-bounded probability of error of a digital communication system from a signal constellation
Audience: Undergraduate

5. Quantify inter-symbol interference in a band-limited digital communication system
Audience: Undergraduate

6. Evaluate the performance of a forward error correction code
Audience: Undergraduate

E C E/M E 439 – INTRODUCTION TO ROBOTICS
3 credits.

Hands-on introduction to key concepts and tools underpinning robotic systems in use and development today. Intended to give students the tools to understand robotic systems, to explore robotics for their own purposes, and to pursue advanced study in the field. Students are expected to have familiarity with a high level programming language such as Python (recommended), MATLAB, Java or Julia.
Requisites: Senior standing or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Predict and control the behavior of common mechatronic actuators
Audience: Undergraduate

2. Predict and interpret the response of common sensors in relation to their environment
Audience: Undergraduate

3. Apply standard algorithms to predict and control the behavior of robotic manipulators
Audience: Undergraduate

4. Interpret the operation of a robot control system and add new functionality to it
Audience: Undergraduate

5. Specify a simple task for a robot, and implement sensors, actuators and a control system to accomplish it
Audience: Undergraduate

6. Analyze the ethical challenges presented by specific robotic applications
Audience: Undergraduate

E C E/M E 441 – KINEMATICS, DYNAMICS, AND CONTROL OF ROBOTIC MANIPULATORS
3 credits.

Robotics analysis and design, focusing on the analytical fundamentals specific to robotic manipulators. Serial chain robotic manipulator forward and inverse kinematics, differential kinematics, dynamics, trajectory generation, and controls. Builds on knowledge of high-level computational programming language such as Matlab.
Requisites: M E 340 and (MATH 320, 340, 341, or 375), graduate/professional standing, or member of Engineering Guest Students. Not open to students with credit for E C E 739 prior to fall 2024.
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Analyze and design serial chain robotic manipulator kinematics
Audience: Both Grad & Undergrad

2. Simulate the dynamic motion of serial chain robotic manipulators
Audience: Both Grad & Undergrad

3. Form the equations of motion for robotic manipulators
Audience: Both Grad & Undergrad

4. Use feedback control for tracking and regulation of robotic manipulators for position, force, and hybrid control
Audience: Both Grad & Undergrad

5. Use trajectory generation methods to design robotic manipulator motion and force trajectories
Audience: Both Grad & Undergrad

6. Analyze the kinematics and controls of more complex serial chain manipulators
Audience: Graduate

7. Design the kinematics of serial chain manipulators using kinematic and dynamics analysis methods
Audience: Graduate

E C E 445 – SEMICONDUCTOR PHYSICS AND DEVICES
3 credits.

Physics and properties of semiconductors, p-n junctions, metal-semiconductor contacts, homojunction and heterojunction bipolar transistor and physics, metal-oxide-semiconductor and heterostructure field-effect transistor and physics, thin-film resistors, memory devices, quantum devices.
Requisites: E C E 335, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2023
Learning Outcomes: 1. Describe basic semiconductor materials and physics, including band structure, charge carriers and transport, phonon, optical and thermal properties, and heterojunctions
Audience: Both Grad & Undergrad

2. Describe semiconductor building blocks and devices, including PN junction, metal-semiconductor contact, metal-oxide-semiconductor capacitor, bipolar junction transistor, metal-oxide-semiconductor field-effect transistor, memory devices
Audience: Both Grad & Undergrad

3. Analyze and design homojunction semiconductor devices
Audience: Graduate

4. Describe basic semiconductor device operation principles, including heterojunction bipolar transistor, meta-semiconductor field-effect transistor, modulation-doped field-effect transistor, high-electron-mobility transistor, and thin-film transistor
Audience: Graduate

5. Critique a paper in the current literature in the field of semiconductor physics
Audience: Graduate

E C E 447 – APPLIED COMMUNICATIONS SYSTEMS
3 credits.

Analysis with design problems of electronic communications circuits. Emphasis on the nonlinear effects of large-signal operation of active devices. Complete design of r.f. oscillator, amplifier, and mixer circuits.
Requisites: E C E 340 and 420, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Apply high-frequency transmission line theory to modeling microwave networks
Audience: Both Grad & Undergrad

2. Use ideal and real transmission lines to design and execute impedance matching networks
Audience: Both Grad & Undergrad

3. Use scattering and noise parameters to design for trade-offs among gain, noise figure, bandwidth, and reflection coefficients in amplifiers
Audience: Both Grad & Undergrad

4. Apply lumped and distributed elements in transistor amplifier design, including design of bias networks
Audience: Both Grad & Undergrad

5. Design and execute filters using microstrip transmission line elements
Audience: Both Grad & Undergrad

6. Apply mixers and directional couplers to microwave measurement principles
Audience: Both Grad & Undergrad

7. Apply negative-resistance amplifier concepts to oscillator design
Audience: Graduate

E C E 453 – EMBEDDED MICROPROCESSOR SYSTEM DESIGN
4 credits.

Hardware and software design for modern microprocessor-based embedded systems; study of the design process; emphasis on major team design project.
Requisites: (E C E 315 and COMP SCI 300) or graduate/professional standing. Not open to special students or students with credit for E C E 454, 455, or 554.
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Design an embedded system that utilizes a commercially available microprocessor
Audience: Undergraduate

2. Incorporate sensors and integrated circuits to solve an engineering problem
Audience: Undergraduate

3. Architect firmware/software solutions used to control embedded systems
Audience: Undergraduate

4. Fabricate a prototype using a printed circuit board (PCB)
Audience: Undergraduate

5. Identify functional requirements and appropriate solutions of an embedded system
Audience: Undergraduate

E C E 454 – MOBILE COMPUTING LABORATORY
4 credits.

End-to-end project management; teamwork; fundamentals of disciplined development practices; introduction to mobile computing platforms and systems; design, implementation, and deployment of mobile systems and applications.
Requisites: COMP SCI 400 or graduate/professional standing. Not open to special students or students with credit for E C E 453, 455, or 554.
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Use a contemporary development environment and programming language to develop mobile applications
Audience: Undergraduate

2. Program the typical functionalities of modern smartphones (e.g., motion sensors, audio/video interface, GPS, and wireless networking modules)
Audience: Undergraduate

3. Work effectively as a member of a team to complete a large programming project while utilizing modern collaboration tools
Audience: Undergraduate

4. Communicate effectively through written reports, oral presentations and discussion
Audience: Undergraduate

5. Review and discuss recent technological advancements in the growing mobile application domain
Audience: Undergraduate

E C E 455 – CAPSTONE DESIGN IN ELECTRICAL AND COMPUTER ENGINEERING
4 credits.

Apply electrical and computer engineering knowledge and skills acquired to real-world electrical and computer engineering design projects.
Requisites: COMP SCI 300, E C E 340, (E C E 303, 304, 305, 306, 308, 313, 315, or 317), senior standing, and declared in Electrical Engineering BS or Computer Engineering BS. Not open to students with credit for E C E 453, 454, or 554.
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Communicate effectively through written reports, oral presentations and discussion
Audience: Undergraduate

2. Review and discuss recent technological advancements in the growing electrical and computer engineering domain
Audience: Undergraduate

3. Work effectively as a member of a team
Audience: Undergraduate

4. Integrate and apply the knowledge gained in prior coursework into a real-world design environment
Audience: Undergraduate

5. Use contemporary commercial design tools
Audience: Undergraduate

6. Realize and demonstrate a hardware prototype
Audience: Undergraduate

E C E/B M E 462 – MEDICAL INSTRUMENTATION
3 credits.

Design and application of electrodes, biopotential amplifiers, biosensors, therapeutic devices. Medical imaging. Electrical safety. Measurement of ventilation, blood pressure and flow.
Requisites: E C E 340, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Solve complicated mathematical problems for electrical and electronic circuits
Audience: Both Grad & Undergrad

2. Employ simulation tools to test and analyze electronic circuits for measuring physiological signals
Audience: Both Grad & Undergrad

3. Design electronic schematics for advanced instrumentation system using software tools
Audience: Both Grad & Undergrad

4. Solder and build advanced instrumentation system for measuring physiological signals
Audience: Both Grad & Undergrad

5. Program a microcontroller to acquire and process physiological signals
Audience: Both Grad & Undergrad

6. Perform experiments using the instrumentation system, analyze data and draw conclusions
Audience: Both Grad & Undergrad

7. Demonstrate an ability to formulate, analyze and, independently design and build instrumentation system to measure physiological signals
Audience: Graduate

E C E/B M E 463 – COMPUTERS IN MEDICINE
3 credits.

Study of microprocessor-based medical instrumentation. Emphasis on real-time analysis of electrocardiograms. Labs and programming project involve design of biomedical digital signal processing algorithms. Knowledge of computer programming language like C, C++ or Java, strongly encouraged.
Requisites: E C E 330 and (COMP SCI 200, 220, 300, 301, or placement into COMP SCI 300), graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Solve complicated mathematical problems with design of digital filters for biomedical signals
Audience: Both Grad & Undergrad

2. Build electrocardiogram (ECG) instrumentation system to view their ECG and use it as an input to a microcontroller for signal analysis
Audience: Both Grad & Undergrad

3. Employ simulation tools to design and test a variety of linear digital filters
Audience: Both Grad & Undergrad

4. Perform experiments, analyze and interpret the performance of digital filters on a database of ECGs
Audience: Both Grad & Undergrad

5. Write microcontroller code for real-time processing of biomedical signals, particularly the ECG, to attenuate diverse noise sources and find clinically-significant features
Audience: Both Grad & Undergrad

6. Demonstrate an ability to formulate and, independently design and implement digital filters and algorithm to process biomedical signals
Audience: Graduate

E C E 466 – ELECTRONICS OF SOLIDS
3 credits.

Electronic, optical and thermal properties of crystalline solids. Energy-momentum dispersion of fundamental particles and excitations in solids leading to microscopic theories of conductivity, polarizability and permeability. Influence of materials characteristics on the performance of electronic and photonic devices.
Requisites: (E C E 305 or 335), graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Construct analytical models to elucidate the physical operation of heterostructure-based devices, including transistors and resonant tunneling diodes
Audience: Both Grad & Undergrad

2. Apply design tradeoffs to electronic device design
Audience: Both Grad & Undergrad

3. Determine the relationship between heterojunction properties and device operation
Audience: Both Grad & Undergrad

4. Determine the relationship between semiconductor material transport properties and device operation
Audience: Both Grad & Undergrad

5. Apply design principles to analyze technical articles related to current device/materials related literature
Audience: Graduate

E C E 489 – HONORS IN RESEARCH
1-3 credits.

Undergraduate honors research projects supervised by faculty members.
Requisites: Consent of instructor
Course Designation: Honors - Honors Only Courses (H)
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

E C E 491 – SENIOR DESIGN PROJECT
3 credits.

Engineering design projects supervised by faculty members.
Requisites: Consent of instructor
Repeatable for Credit: No
Last Taught: Spring 2024

E C E 504 – ELECTRIC MACHINE & DRIVE SYSTEM LABORATORY
2-3 credits.

Steady state and dynamic performance of electric machines in combination with power electronic converters. Parameter measurement, performance evaluation, design of experimental procedures for problem solving, use of digital data acquisition systems and signal processing equipment in system evaluation.
Requisites: E C E 711 or concurrent enrollment
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E/COMP SCI 506 – SOFTWARE ENGINEERING
3 credits.

Ideas and techniques for designing, developing, and modifying large software systems. Topics include software engineering processes; requirements and specifications; project team organization and management; software architectures; design patterns; testing and debugging; and cost and quality metrics and estimation. Students will work in large teams on a substantial programming project.
Requisites: (COMP SCI 367 or 400) and (COMP SCI 407, 536, 537, 545, 559, 564, 570, 679 or E C E/COMP SCI 552) or graduate/professional standing, or declared in the Capstone Certificate in Computer Sciences for Professionals
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

E C E 511 – THEORY AND CONTROL OF SYNCHRONOUS MACHINES
3 credits.

The idealized three phase synchronous machine time domain model including saliency, time invariant form using Park's transformation, sudden short circuits and other transient conditions, reduced order models, excitation system and turbine/governor control, dynamics of multiple machine systems, transient stability and subsynchronous resonance.
Requisites: E C E 411 and 427, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Summer 2024
Learning Outcomes: 1. Use equivalent circuit models of synchronous machines for studying their performance
Audience: Both Grad & Undergrad

2. Apply computer simulations of synchronous machines to verify the performance characteristics
Audience: Both Grad & Undergrad

3. Develop torque and speed regulator systems for synchronous machines

Audience: Both Grad & Undergrad

4. Analyze the performance of synchronous machines as generators
Audience: Both Grad & Undergrad

5. Predict the behavior of synchronous machines during external faults
Audience: Graduate

E C E 512 – POWER ELECTRONICS LABORATORY
3 credits.

This laboratory introduces the student to measurement and simulation of important operating characteristics of power electronic circuits and power semiconductor devices. Emphasis is on devices, circuits, gating methods and power quality.
Requisites: E C E 412, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Construct and test hardware prototype of power electronic circuits
Audience: Both Grad & Undergrad

2. Develop and test software controllers for power electronic circuits
Audience: Both Grad & Undergrad

3. Design, layout, fabricate board, procure components, assemble and test a power electronic circuit prototype
Audience: Both Grad & Undergrad

4. Design a power electronic system including start-up, scheduling and housekeeping functions
Audience: Graduate

E C E/COMP SCI/I SY E 524 – INTRODUCTION TO OPTIMIZATION
3 credits.

Introduction to mathematical optimization from a modeling and solution perspective. Formulation of applications as discrete and continuous optimization problems and equilibrium models. Survey and appropriate usage of basic algorithms, data and software tools, including modeling languages and subroutine libraries.
Requisites: (COMP SCI 200, 220, 300, 301, 302, 310, or placement into COMP SCI 300) and (MATH 320, 340, 341, or 375) or graduate/professional standing
Course Designation: Breadth - Natural Science
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Engage in topics about "optimization in practice".
Audience: Undergraduate

2. Use and analyze the results of state of the art optimization software.
Audience: Undergraduate

3. Use the GAMS modeling system and Jupyter notebooks (in conjunction with elementary Python) or Julia and JUMP.
Audience: Undergraduate

4. Design good models for realistic applications in engineering and the sciences.
Audience: Undergraduate

5. Develop a "commercial strength" application of optimization technology.
Audience: Undergraduate

E C E/N E/PHYSICS 525 – INTRODUCTION TO PLASMAS
3 credits.

Basic description of plasmas: collective phenomena and sheaths, collisional processes, single particle motions, fluid models, equilibria, waves, electromagnetic properties, instabilities, and introduction to kinetic theory and nonlinear processes. Examples from fusion, astrophysical and materials processing processing plasmas.
Requisites: (E C E 320 or PHYSICS 322), graduate/professional standing, or member of Engineering Guest Students
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E/N E/PHYSICS 527 – PLASMA CONFINEMENT AND HEATING
3 credits.

Principles of magnetic confinement and heating of plasmas for controlled thermonuclear fusion: magnetic field structures, single particle orbits, equilibrium, stability, collisions, transport, heating, modeling and diagnostics. Discussion of current leading confinement concepts: tokamaks, tandem mirrors, stellarators, reversed field pinches, etc.
Requisites: E C E/N E/PHYSICS 525, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E/N E 528 – PLASMA PROCESSING AND TECHNOLOGY
3 credits.

Introduction to basic understanding and techniques. Plasma processing of materials for semiconductors, polymers, plasma spray coatings, ion implantation, etching, arcs, extractive metallurgy and welding. Plasma and materials diagnostics.
Requisites: PHYSICS 322 or E C E 320, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2021

E C E/COMP SCI/M E 532 – MATRIX METHODS IN MACHINE LEARNING
3 credits.

Linear algebraic foundations of machine learning featuring real-world applications of matrix methods from classification and clustering to denoising and data analysis. Mathematical topics include: linear equations, regression, regularization, the singular value decomposition, and iterative algorithms. Machine learning topics include: the lasso, support vector machines, kernel methods, clustering, dictionary learning, neural networks, and deep learning. Previous exposure to numerical computing (e.g. Matlab, Python, Julia, R) required.
Requisites: (MATH 234, 320, 340, 341, or 375) and (E C E 203, COMP SCI 200, 220, 300, 301, 302, 310, 320, or placement into COMP SCI 300), graduate/professional standing, or declared in Capstone Certificate in Computer Sciences for Professionals
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Use matrices and vectors to formulate classification, prediction and matrix completion problems using techniques such as least squares, regularized least squares, the singular value decomposition, subspace methods, support vector machines, neural networks and kernel methods.
Audience: Both Grad & Undergrad

2. Implement machine learning techniques for classification, prediction and matrix completion problems in software, and validate their performance on datasets using cross validation.
Audience: Both Grad & Undergrad

3. Apply advanced techniques to formulate and prove optimality of various matrix based techniques in machine learning.
Audience: Graduate

E C E/COMP SCI 533 – IMAGE PROCESSING
3 credits.

Mathematical representation of continuous and digital images; models of image degradation; picture enhancement, restoration, segmentation, and coding; pattern recognition, tomography.
Requisites: E C E 330 and (MATH 320 or 340), graduate/professional standing, or member of Engineering Guest Students
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

E C E 536 – INTEGRATED OPTICS AND OPTOELECTRONICS
3 credits.

Characteristics of semiconductors; study of physical mechanisms and modeling of solid state electronic and photonic devices; principles of optoelectronic processing and examples of integrated optoelectronics.
Requisites: E C E 335 and (E C E 420 or 434), graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2023
Learning Outcomes: 1. Evaluate and analyze the physical operation of optoelectronic devices, such as waveguides, lasers, and photodetectors
Audience: Both Grad & Undergrad

2. Apply the design tradeoffs to optoelectronic devices
Audience: Both Grad & Undergrad

3. Evaluate the basic optoelectronic processing techniques for device fabrication
Audience: Both Grad & Undergrad

4. Evaluate basic compound semiconductor materials and their properties

Audience: Both Grad & Undergrad

5. Review and assess current literature in the field of optoelectronics
Audience: Graduate

E C E 537 – COMMUNICATION NETWORKS
3 credits.

Study of communication networks with focus on performance analysis. Layered network structure. Basic protocol functions such as addressing, multiplexing, routing, forwarding, flow control, error control, and congestion response. Overview of transport, network, and link layer protocol standards. Introduction to wireless and mobile networks.
Requisites: E C E 203 and (COMP SCI 400 or 367 prior to Fall 2018), graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Identify the components of present-day communication networks
Audience: Undergraduate

2. Characterize the components and the corresponding functions of Internet infrastructure
Audience: Undergraduate

3. Determine how information is transferred from one end to the other reliably and efficiently and re-create the same
Audience: Undergraduate

4. Analyze and evaluate the underlying algorithms and protocols in a communication network
Audience: Undergraduate

E C E/COMP SCI/M E 539 — INTRODUCTION TO ARTIFICIAL NEURAL NETWORKS
3 credits.

Theory and applications of artificial neural networks: multi-layer perceptron, self-organization mapdeep neural network convolutional neural network, recurrent network, support vector machines genetic algorithm, and evolution computing. Applications to control, pattern recognition, prediction, and object detection and tracking.
Requisites: COMP SCI 200, 220, 300, 301, 302, 310, placement into COMP SCI 300, or graduate/professional standing
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Identify if a given data analysis task is a pattern classification problem or a model approximation problem.
Audience: Undergraduate

2. Apply multi-layer perceptron neural network training algorithm to develop artificial neural network (ANN) based pattern classifiers and data predictors.
Audience: Undergraduate

3. Apply deep learning network for pattern classification
Audience: Undergraduate

4. Apply support vector machine (SVM) to develop pattern classifiers.
Audience: Undergraduate

5. Apply self-organization map and k-means to perform clustering operations of a given data set.
Audience: Undergraduate

6. Apply stochastic optimization methods, including simulated annealing, genetic algorithm and random search to solve a discrete optimization problem.
Audience: Undergraduate

E C E 541 — ANALOG MOS INTEGRATED CIRCUIT DESIGN
3 credits.

Analysis, design and applications of modern analog circuits using integrated bipolar and field-effect transistor technologies. Provides the student with a working knowledge of the basic circuits used in modern analog integrated circuits and techniques for analysis and design.
Requisites: E C E 340, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2017
Learning Outcomes: 1. Master the functions and DC and AC operations of metal-oxide-semiconductor field transistors and bipolar junction transistors for analog integrated circuits
Audience: Both Grad & Undergrad

2. Analyze, design and simulate single stage and multiple stage analog amplifiers
Audience: Both Grad & Undergrad

3. Analyze, design and simulate current references, voltage references, and output stages for analog amplifiers
Audience: Both Grad & Undergrad

4. Analyze, design and simulate basic operational amplifiers
Audience: Both Grad & Undergrad

5. Analyze, design and simulate analog amplifiers utilizing negative feedback
Audience: Both Grad & Undergrad

6. Analyze, design and simulate analog amplifiers considering frequency response and stability
Audience: Graduate

E C E 542 – INTRODUCTION TO MICROELECTROMECHANICAL SYSTEMS
3 credits.

Introduction to MEMS technology, devices and systems. Fundamentals of MEMS in fabrication, process integration, material mechanics of MEMS structures, sensors and actuators. Main topics in MEMS - microfluidics, optical MEMS, RF MEMS, BioMEMS, packaging, and CAD.
Requisites: (E C E 335 or 340), graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2023
Learning Outcomes: 1. Master fundamental fabrication techniques in integrated circuits and microelecromechanical systems (MEMS)
Audience: Both Grad & Undergrad

2. Analyze and construct fabrication process flows for MEMS
Audience: Both Grad & Undergrad

3. Analyze and design mechanical structures for MEMS
Audience: Both Grad & Undergrad

4. Analyze and design mechanical sensors and actuators
Audience: Both Grad & Undergrad

5. Analyze thermal and magnetic transducers, microfluidics, lab on chips, optical MEMS devices and radio frequency MEMS devices
Audience: Both Grad & Undergrad

6. Design systems integrating MEMS devices with integrated circuits
Audience: Graduate

E C E 545 – ADVANCED MICROWAVE MEASUREMENTS FOR COMMUNICATIONS
3 credits.

Measurements at VHF and microwave frequencies; characteristics of microwave generators, amplifiers, passive devices and detection systems; measurement of frequency, noise and simple antenna patterns; time domain reflectometry, swept frequency network and spectrum analyzer techniques; lecture and lab.
Requisites: (E C E 440 or 447), graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2021

E C E 547 – ADVANCED COMMUNICATIONS CIRCUIT DESIGN
3 credits.

Principles underlying the design of r.f. and microwave communications circuits. Analysis and design of wideband nonlinear power amplifiers, S-parameter techniques for r.f. active circuit design, computer aided design techniques, r.f. integrated circuits, fundamentals of low noise r.f. design.
Requisites: (E C E 420 or 447), graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E 548 – INTEGRATED CIRCUIT DESIGN
3 credits.

Bipolar and MOS devices in monolithic circuits. Device physics, fabrication technology. IC-design for linear and nonlinear circuitry.
Requisites: E C E 335, graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Solve problems related to operation and fabrication of semiconductor devices (diodes, BJTs, MOSFETs)
Audience: Undergraduate

2. Draw semiconductor band diagrams and apply these drawings to explain effects that appear at interfaces between materials such as differently doped semiconductors, semiconductor-metal interface
Audience: Undergraduate

3. Analyze advanced effects that appear in MOSFETs when their size is reduced to nanometer scale
Audience: Undergraduate

4. Develop and design device physics models using simulation platform such as TCAD
Audience: Undergraduate

E C E 549 – INTEGRATED CIRCUIT FABRICATION LABORATORY
4 credits.

Monolithic integrated circuit fabrication; mask making, photolithography, oxidation, diffusion, junction evaluation, metallization, packaging, and testing.
Requisites: (E C E 335 or 548), graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Analyze, design and execute process flow used during semiconductor device fabrication
Audience: Both Grad & Undergrad

2. Perform simple electrical measurements of MOSFET transistors
Audience: Both Grad & Undergrad

3. Explain operating principles of clean room tools such as mask aligner, plasma etcher, metal deposition sputterer, etc.
Audience: Both Grad & Undergrad

4. Perform silicon processing steps in the clean room such as lithography, wet and dry etching, and metal deposition
Audience: Both Grad & Undergrad

5. Solve engineering problems related to silicon processing
Audience: Both Grad & Undergrad

6. Design and perform advanced electrical measurements of MOSFET devices
Audience: Graduate

E C E 551 – DIGITAL SYSTEM DESIGN AND SYNTHESIS
3 credits.

Introduction to the use of hardware description languages and automated synthesis in design. Advanced design principles. Verilog and VHDL description languages. Synthesis from hardware description languages. Timing-oriented synthesis. Relation of integrated circuit layout to timing-oriented design. Design for reuse.
Requisites: E C E/COMP SCI 352, graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Describe a digital design using a Hardware Description Language (HDL) such that it will synthesize efficiently using the intended mix of sequential and combinational cells. Demonstrate proficiency in coding in both dataflow and behavioral HDL styles
Audience: Undergraduate

2. Write a thorough testbench to validate a digital design. This includes consideration of corner test cases and ensuring testbench is self-checking

Audience: Undergraduate

3. Simulate and debug a digital design using a HDL simulator
Audience: Undergraduate

4. Constrain and Synthesize a digital design targeting a standard cell library. Explore options and methods to optimize synthesis results for speed/power/area. Interpret static timing reports generated by synthesis tool
Audience: Undergraduate

5. Partition and complete the implementation (design/validation/synthesis) of a complex digital system as a member of a project team
Audience: Undergraduate

E C E/COMP SCI 552 – INTRODUCTION TO COMPUTER ARCHITECTURE
3 credits.

The design of computer systems and components. Processor design, instruction set design, and addressing; control structures and microprogramming; memory management, caches, and memory hierarchies; and interrupts and I/O structures. E C E 551 or knowledge of Verilog is recommended.
Requisites: (E C E/COMP SCI 352 and E C E/COMP SCI 354) or graduate/professional standing
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

E C E 553 – TESTING AND TESTABLE DESIGN OF DIGITAL SYSTEMS
3 credits.

Faults and fault modeling, test equipment, test generation for combinational and sequential circuits, fault simulation, memory and microprocessor testing, design for testability, built-in self-test techniques, and fault location.
Requisites: COMP SCI/E C E 352 and COMP SCI 300, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Identify factors that impact economics of testing of integrated circuits
Audience: Both Grad & Undergrad

2. Model and simulate faults that can occur in integrated circuits
Audience: Both Grad & Undergrad

3. Apply state-of-the-art test generation algorithms
Audience: Both Grad & Undergrad

4. Utilize design for testability and built-in self-test techniques
Audience: Both Grad & Undergrad

5. Generate tests to detect path delay faults
Audience: Graduate

E C E 554 – DIGITAL ENGINEERING LABORATORY
4 credits.

Practical aspects of computer system design. Design, construction, and testing of significant digital subsystems. Design, construction, and programming of pipelined digital computers.
Requisites: E C E 551 and E C E/COMP SCI 552. Not open to special students or students with credit for E C E 453, 454 or 455.
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Specify a novel instruction set architecture (ISA)
Audience: Undergraduate

2. Specify the design of a processor that implements a novel ISA
Audience: Undergraduate

3. Develop, verify, and demonstrate a working prototype of a processor
Audience: Undergraduate

4. Collaborate effectively as a member of a moderate-sized team
Audience: Undergraduate

5. Communicate project status and results effectively both orally and in writing
Audience: Undergraduate

E C E 555 – DIGITAL CIRCUITS AND COMPONENTS
3 credits.

Principles and characterization of logic circuits. Design and analysis techniques for applied logic circuits. Transmission lines in digital applications. Families of circuit logic currently in use and their characteristics.
Requisites: (E C E/COMP SCI 352 and E C E 340), graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Summarize theory of advanced MOS devices and operations
Audience: Undergraduate

2. Identify challenges and solutions in scaling of CMOS devices
Audience: Undergraduate

3. Analyze power, performance, area metrics for CMOS logic families
Audience: Undergraduate

4. Analyze design of sequential circuits with timing constraints
Audience: Undergraduate

5. Produce circuit schematic and layout in CAD tools
Audience: Undergraduate

6. Test transient behavior of circuits in simulation tools
Audience: Undergraduate

7. Describe operation of VLSI memory and identify critical components
Audience: Undergraduate

E C E 556 – DESIGN AUTOMATION OF DIGITAL SYSTEMS
3 credits.

Use of digital computers to simulate, partition, place and interconnect digital electronic systems.
Requisites: E C E/COMP SCI 352 and (COMP SCI 300 or 367 prior to Fall 2018), graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2024
Learning Outcomes: 1. Identify different steps of the design flow of integrated circuits
Audience: Undergraduate

2. Map a high-level netlist in Verilog to a gate-level logic circuit using a standard-cell library
Audience: Undergraduate

3. Identify different steps of layout design including placement, global, and detailed routing
Audience: Undergraduate

4. Perform static timing analysis in a combinational logic circuit
Audience: Undergraduate

5. Identify and apply physical-synthesis techniques in integrated circuits such as gate sizing and logic restructuring
Audience: Undergraduate

E C E/COMP SCI 561 – PROBABILITY AND INFORMATION THEORY IN MACHINE LEARNING
3 credits.

Probabilistic tools for machine learning and analysis of real-world datasets. Introductory topics include classification, regression, probability theory, decision theory and quantifying information with entropy, relative entropy and mutual information. Additional topics include naive Bayes, probabilistic graphical models, discriminant analysis, logistic regression, expectation maximization, source coding and variational inference.
Requisites: (MATH 320, 340, 341, 375, or M E/COMP SCI/E C E 532 or concurrent enrollment) and (E C E 331, STAT/MATH 309, 431, STAT 311, 324, M E/STAT 424 or MATH 531) or grad/profsnl standing or declared in Capstone Certificate in Computer Sciences for Professionals
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Identify how ambiguity and noise leads to the need for probabilistic methods in machine learning
Audience: Both Grad & Undergrad

2. Implement classification, prediction and generative algorithms using a variety of techniques based in probability, information theory and machine learning
Audience: Both Grad & Undergrad

3. Prove optimality of a variety of algorithms and demonstrate understanding of sample complexity bounds
Audience: Graduate

E C E/I SY E 570 – ETHICS OF DATA FOR ENGINEERS
3 credits.

Introduction to ethical issues in data engineering and principled solutions. Algorithmic fairness (individual fairness, group fairness, counterfactual fairness), differential privacy and its applications, and robustness.
Requisites: (I SY E 521, 562, M E/COMP SCI/E C E 532, or 539) and (E C E 331, MATH/STAT 309, STAT 311, MATH 331, or STAT/MATH 431), or graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Describe the importance of ethical data science/engineering
Audience: Both Grad & Undergrad

2. Identify challenges of trustworthy data use in engineering such as fairness, privacy, and robustness
Audience: Both Grad & Undergrad

3. Apply the definitions of trustworthy data engineering to real-world datasets
Audience: Both Grad & Undergrad

4. Analyze the data analysis pipelines and evaluate the trustworthiness of their outcomes
Audience: Both Grad & Undergrad

5. Create proper data analysis pipelines with ethical considerations
Audience: Both Grad & Undergrad

6. Implement cutting-edge techniques to enhance the fairness, privacy, and robustness of data analysis processes
Audience: Graduate

7. Conduct independent research on emerging challenges in ethical data engineering
Audience: Graduate

E C E/M E 576 – PRINTED AND FLEXIBLE ELECTRONICS: MANUFACTURING, DEVICES, AND APPLICATIONS
3 credits.

Exploration of additive fabrication of thin-film electronics. Various techniques, materials, and applications of printable electronics with a key focus on mechanically flexible electronic devices. Identify the appropriate printing technology and materials to achieve desired device performance.
Requisites: E C E 230 or 376, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Define the broad field of printed/thin-film electronics
Audience: Both Grad & Undergrad

2. Describe the multiple techniques for printing electronics
Audience: Both Grad & Undergrad

3. Identify the appropriate technique for specific target applications
Audience: Both Grad & Undergrad

4. Describe applications of materials for insulating, conducting, and semiconducting, required for advanced thin-film electronics
Audience: Both Grad & Undergrad

5. Benchmark printed devices including sensors and thin-film transistors
Audience: Both Grad & Undergrad

6. Design printable electronic sensors to desired specifications
Audience: Graduate

7. Describe the current challenges of the field of printable electronics
Audience: Graduate

E C E/M E 577 – AUTOMATIC CONTROLS LABORATORY
4 credits.

Control theory is reduced to engineering practice through the analysis and design of actual systems in the laboratory. Experiments are conducted with modern servo systems using both analog and digital control. Systems identification and modern controls design are applied to motion and torque control.
Requisites: M E 346 or E C E 332, or graduate/professional standing or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2024

E C E 601 – SPECIAL TOPICS IN ELECTRICAL AND COMPUTER ENGINEERING
1-4 credits.

Advanced topics of special interest to students in various areas of Electrical and Computer Engineering.
Requisites: Junior standing or member of Engineering Guest Students
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2024

E C E 610 – SEMINAR IN ELECTRICAL AND COMPUTER ENGINEERING
1 credit.

Survey of topics within the department of electrical and computer engineering that introduce students to the materials/techniques to assist them in being successful graduate students. Faculty seminars spanning energy and power systems, applied physics, electromagnetic fields, plasmas, communications and signal processing, controls, photonics, solid state, and computers will be given. Additionally, students will participate in weekly group exercises to enhance their skills in engineering/technical communications, writing, ethics, and project management.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

E C E 611 – INTRODUCTION TO DOCTORAL RESEARCH IN ELECTRICAL & COMPUTER ENGINEERING
2 credits.

A focus on topics within the department of electrical and computer engineering that introduce students to the materials/techniques that will assist them in being successful graduate students. Faculty seminars spanning energy and power systems, applied physics, electromagnetic fields, plasmas, communications and signal processing, controls, photonics, solid state, and computers will be given. Additionally, students will participate in weekly group exercises to enhance their skills in engineering/technical communications, writing, ethics, and project management. Graded homework and a final project are assigned.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E/MATH 641 – INTRODUCTION TO ERROR-CORRECTING CODES
3 credits.

Coding theory. Codes (linear, Hamming, Golay, dual); decoding-encoding; Shannon's theorem; sphere-packing; singleton and Gilbert-Varshamov bounds; weight enumerators; MacWilliams identities; finite fields; other codes (Reed-Muller, cyclic, BCH, Reed-Solomon) and error-correction algorithms.
Requisites: MATH 541 or graduate/professional standing or member of the Pre-Masters Mathematics (Visiting International) Program
Course Designation: Breadth - Natural Science
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2017

E C E 697 – CAPSTONE PROJECT IN MACHINE LEARNING AND SIGNAL PROCESSING
5 credits.

Individual or team project to gain hands-on-experience applying machine learning and signal processing concepts.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Summer 2024
Learning Outcomes: 1. Identify a real-world problem that can be addressed and answered using techniques in machine learning and signal processing
Audience: Graduate

2. Think critically about the end-to-end formulation of a real-world machine learning and signal processing task
Audience: Graduate

3. Apply MLSP concepts to a real-world machine learning and signal processing task
Audience: Graduate

4. Ask and answer deep and driving questions about a machine learning and signal processing project
Audience: Graduate

5. Gain, sharpen, and showcase skills in teamwork, problem solving, reflection, and communication
Audience: Graduate

E C E 699 — ADVANCED INDEPENDENT STUDY
1-6 credits.

Directed study projects as arranged with instructor.
Requisites: Consent of instructor
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

E C E 702 — GRADUATE COOPERATIVE EDUCATION PROGRAM
1-2 credits.

Work experience that combines classroom theory with practical knowledge of operations to provide students with a background on which to develop and enhance a professional career. The work experience is tailored for MS students from within the U.S. as well as eligible international students.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025
Learning Outcomes: 1. Identify and respond appropriately to real-life engineering ethics cases relevant to co-op work
Audience: Graduate

2. Synthesize and apply appropriate technical education to real world technical work
Audience: Graduate

3. Communicate effectively in writing and speaking with a range of audiences in the workplace, including those without disciplinary expertise
Audience: Graduate

4. Develop professional and transferable habits like time management skills, collaborative problem-solving skills, and research skills for learning new information
Audience: Graduate

E C E/COMP SCI 707 — MOBILE AND WIRELESS NETWORKING
3 credits.

Design and implementation of protocols, systems, and applications for mobile and wireless networking, particularly at the media access control, network, transport, and application layers. Focus is on the unique problems and challenges presented by the properties of wireless transmission, various device constraints such as limited battery power, and node mobility. Knower of computer networking is strongly encouraged, such as from COMP SCI 640 or E C E 537.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

E C E 711 — DYNAMICS AND CONTROL OF AC DRIVES
3 credits.

Principles of power converters, two axis models of AC machines and AC drives, simulation of drive systems, analytical modeling of drives, dynamic behavior of induction and synchronous motors and drive systems. Knowledge of Simulink required.
Requisites: E C E 411 and (graduate/professional standing or declared in Capstone Certificate in Power Conversion and Control)
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2024
Learning Outcomes: 1. Develop coupled circuit model of ac machines, including induction and synchronous machines
Audience: Graduate

2. Develop complex variable model of induction machines
Audience: Graduate

3. Perform digital simulation of electric machines and drives
Audience: Graduate

4. Develop DQ models for power converters and current regulation
Audience: Graduate

5. Develop field orientation control, vector control, and direct torque control
Audience: Graduate

6. Develop small-signal dynamic response of electric machines
Audience: Graduate

E C E 712 — SOLID STATE POWER CONVERSION
3 credits.

Advanced course in power electronics which provides an understanding of switching power converters. Included are DC-to-DC, AC-to-DC, DC-to-AC, and AC-to-AC converters, commutation techniques, converter control, interfacing converters with real sources and loads.
Requisites: E C E 412 and graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E 713 — ELECTROMAGNETIC DESIGN OF AC MACHINES
3 credits.

Electromagnetic design concepts and application to AC machines, magnetic circuit concepts, calculation of equivalent circuit parameters of induction, synchronous and permanent magnet machines from geometric data, copper and iron loss calculations, theory and application of finite elements to electromagnetic devices.
Requisites: (E C E 411 or 511) and graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E 714 – UTILITY APPLICATION OF POWER ELECTRONICS
3 credits.

Power electronic application to utility systems is a rapidly growing field with major impact on the industry. Covers material on HVDC transmission, energy storage systems, renewable sources, static compensators, and flexible ac transmission systems.
Requisites: E C E 412, 427, and graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

E C E 717 – LINEAR SYSTEMS
3 credits.

Equilibrium points and linearization; natural and forced response of state equations; system equivalence and Jordan form; Lyapunov, asymptotic, and BIBO stability; controllability and duality; control-theoretic concepts such as pole-placement, stabilization, observers, dynamic compensation, and the separation principle. Knowledge of linear algebra [such as MATH 340] required.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

E C E/B M I/COMP SCI/MED PHYS 722 – COMPUTATIONAL OPTICS AND IMAGING
3 credits.

Computational imaging includes all imaging methods that produce images as a result of computation on collected signals. Learn the tools to design new computational imaging methods to solve specific imaging problems. Provides an understanding of the physics of light propagation and measurement, and the computational tools to model it, including wave propagation, ray tracing, the radon transform, and linear algebra using matrix and integral operators and the computational tools to reconstruct an image, including linear inverse problems, neural networks, convex optimization, and filtered back-projection. Covers a variety of example computational imaging techniques and their applications including coded apertures, structured illumination, digital holography, computed tomography, imaging through scattering media, compressed sensing, and non-line-of-sight imaging.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Apply ray and wave based light propagation models
Audience: Graduate

2. Explain the process of image formation in conventional imaging systems using theory and computational models
Audience: Graduate

3. Select and combine the different components required in an imaging system to perform light manipulation, collection, and image reconstruction

Audience: Graduate

4. Apply the linear matrix and integral operators that model light propagation
Audience: Graduate

5. Apply the linear inverse algorithms that allow an imaging system to reconstruct properties of the scene from collected data
Audience: Graduate

6. Simulate different computational imaging systems and perform computation on simulated datasets
Audience: Graduate

7. Understand the most common computational imaging techniques and be able to use and adapt them for their own applications
Audience: Graduate

E C E 723 – ON-LINE CONTROL OF POWER SYSTEMS
3 credits.

State estimation based on line-flow measurements. Detection and correction of incorrect on-line measurements. Reduction techniques. Network security evaluation. On-line contingency studies and contingency remedial action. Calculation of penalty factors and optimal power dispatch strategies. On-line stability determination. Parallel processors for on-line studies. Knowledge of basic probability analysis [such as E C E 331, STAT/MATH 431, or STAT 311] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2024

E C E/N E/PHYSICS 724 – WAVES AND INSTABILITIES IN PLASMAS
3 credits.

Waves in a cold plasma, wave-plasma interactions, waves in a hot plasma, Landau damping, cyclotron damping, magneto-hydrodynamic equilibria and instabilities, microinstabilities, introduction to nonlinear processes, and experimental applications. Basic knowledge of plasmas [such as PHYSICS/E C E/N E 525] and advanced electromagnetics [such as PHYSICS 721 or E C E 740] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E/N E/PHYSICS 725 – PLASMA KINETIC THEORY AND RADIATION PROCESSES
3 credits.

Coulomb Collisions, Boltzmann equation, Fokker-Planck methods, dynamical friction, neoclassical diffusion, collision operators radiation processes and experimental applications. Basic knowledge of plasmas [such as PHYSICS/E C E/N E 525] and advanced electromagnetics [such as PHYSICS 721 or E C E 740] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2024

E C E/N E/PHYSICS 726 – PLASMA MAGNETOHYDRODYNAMICS
3 credits.

MHD equations and validity in hot plasmas; magnetic structure and magnetic flux coordinates; equilibrium in various configurations; stability formulation, energy principle, classification of instabilities; ideal and resistive instability in various configurations, evolution of nonlinear tearing modes; force-free equilibria, helicity, MHD dynamo; experimental applications. Basic knowledge of plasmas [such as PHYSICS/E C E/N E 525] and advanced electromagnetics [such as PHYSICS 721 or E C E 740] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

E C E 729 – INFORMATION THEORY
3 credits.

Definition of measures of information and their properties, capacity of discrete and continuous channels with noise, source and channel coding theorems, fundamentals of channel coding, noiseless source coding, and source coding with a fidelity criterion. Knowledge of basic probability analysis [such as E C E 331, STAT/MATH 431, or STAT 311] required.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2022
Learning Outcomes: 1. Calculate the entropy of a random variable from its distribution, the mutual information between two random variables from their joint distribution, the Kullback-Leibler divergence between two probability distributions, and the entropy rate of a Markov process
Audience: Graduate

2. Construct source codes such as the Huffman code, the Shannon code, and the Elias-Fano code for a given probability distribution of the source
Audience: Graduate

3. Define channel capacity and apply Shannon's channel coding theorem to Calculate the channel capacities of discrete channels such as the binary symmetric channel and the binary erasure channel, and continuous channels such as the additive Gaussian noise channel
Audience: Graduate

E C E 730 – PROBABILITY AND RANDOM PROCESSES
3 credits.

Review of basic probability. Advanced probability concepts. Random vectors; linear filtering of random processes; stationarity; power spectral densities; estimation; convergence; Markov chains; Poisson process; Wiener process. Knowledge of basic probability analysis [such as E C E 331, STAT/MATH 431, or STAT 311] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Compute probabilities and expectations using probability mass functions and densities together with the laws of total probability and substitution, along with the property of independence when applicable
Audience: Graduate

2. Work with Gaussian random vectors, joint densities, and characteristic functions
Audience: Graduate

3. Determine in what sense(s) a sequence of random variables converges
Audience: Graduate

4. Perform calculations using properties of the Poisson process and the Wiener process
Audience: Graduate

E C E 731 – ADVANCED POWER SYSTEM ANALYSIS
3 credits.

Electrical transients due to faults and switching. Effect on power system design and operation. Traveling waves and surge protection. Computerized analysis of power transients.
Requisites: E C E 427 and graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2021

E C E/M E 732 – DYNAMICS OF CONTROLLED SYSTEMS
3 credits.

Emphasis on obtaining equations which define the behavior of physical systems frequently subjected to control; mechanical processing, fluid power, and thermal systems; analytical, experimental, and computer techniques. Knowledge of Automatic Controls [such as M E 446 or E C E 322] is required.
Requisites: Graduate/professional standing. Not open to students with credit for M E 746.
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Describe how physical state feedback affects dynamic stiffness of a control system
Audience: Graduate

2. Analyze the sensitivity of the system with eigenvalue migration analysis
Audience: Graduate

3. Develop improved control systems by implementing active state feedback which mimics the physical system and augments the system performance
Audience: Graduate

4. Differentiate command tracking from disturbance rejection. The student will characterize the necessary command feedforward structure in order to achieve optimal command tracking.
Audience: Graduate

5. Manipulate observer inputs and state feedback inputs to achieve zero-lag properties
Audience: Graduate

6. Draw the block diagram of physical systems identifying the appropriate inputs required for a properly formed observer
Audience: Graduate

7. Implement observers for state estimation in multi-variable control systems
Audience: Graduate

E C E/M E 733 – ADVANCED COMPUTER CONTROL OF MACHINES AND PROCESSES
3 credits.

Digital control theory, design methodology, and techniques for controller implementation on digital computers. Advanced single and multi-axis motion generation algorithms. Multiple processor control systems. Multiple objective control systems for machinery guidance and manufacturing processes. Precision control. Knowledge of continuous and discrete time control [such as M E 447 or E C E 332] is required.
Requisites: Graduate/professional standing. Not open to students with credit for M E 747.
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Learning Outcomes: 1. Explain and apply physics-based discrete time system modeling
Audience: Graduate

2. Analyze and design in both the continuous and discrete domains
Audience: Graduate

3. Analyze and design control systems using tools such as Matlab and Simulink
Audience: Graduate

4. Describe physics-based control structures for computer control systems
Audience: Graduate

E C E 734 – VLSI ARRAY STRUCTURES FOR DIGITAL SIGNAL PROCESSING
3 credits.

An overview of the architectures and design methodologies of VLSI array processors for digital signal processing. Emphasis is placed on the techniques of mapping algorithms onto array structures for real time signal processing. Knowledge of digital signal processing [such as E C E 431] and computer architecture [such as E C E/COMP SCI 552] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2022

E C E 735 – SIGNAL SYNTHESIS AND RECOVERY TECHNIQUES
3 credits.

Signals and their representation. Signal synthesis subject to constraints on peak voltage, energy, duration-bandwidth product. The theory of alternating projections onto convex sets and applications to inverse problems in signal processing: signal recovery using incomplete data, image recovery in tomography using limited views, phase retrieval in optical astronomy.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2020

E C E 736 — WIRELESS COMMUNICATIONS
3 credits.

Theory, design and analysis of mobile wireless communication systems from a signal processing perspective. Emphasis on code-division multiple-access (CDMA) systems employing direct-sequence spread-spectrum (DS-SS) signaling. Topics include characterization of mobile wireless channels, demodulation of DS-SS signals, diversity techniques, interference suppression methods, and low-complexity adaptive receivers. Knowledge of probability [such as E C E 730] and digital communication [such as E C E 437] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E 738 — ADVANCED DIGITAL IMAGE PROCESSING
3 credits.

Deterministic and stochastic spatio-temporal image models, transform domain processing, Markov random fields and anisotropic diffusion; MAP parameter estimation, ill-posed inverse problems, robust statistics and non-linear digital filtering in image processing. Applications to image restoration, motion estimation, (video) image compression (MPEG, JPEG) and tomography. Knowledge of image processing [such as E C E/ COMP SCI 533] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E 740 — ELECTROMAGNETIC THEORY
3 credits.

Time harmonic fields and waves in linear media with applications to radiation, guiding and scattering; wave and surface impedance and admittance concepts; duality, uniqueness, image theory, equivalence principle, induction and compensation theorems, reciprocity, Green's functions, wave functions, potential and transform theory. Knowledge of electromagnetics [such as E C E 420] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

E C E 741 — SEMICONDUCTOR DIODE LASERS AND OTHER OPTOELECTRONIC DEVICES
3 credits.

An overview of modern photonic technology and an introduction to key parameters and concepts; the basic mechanisms determining the relationship between optical gain and current density, and quantum-well laser structures; physics of high-power phase-locked laser arrays or other optoelectronics devices. Knowledge of electromagnetics [such as E C E 320] and solid-state electronics [such as E C E 335] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2024
Learning Outcomes: 1. Apply simulation tools to characterize the physical operation of semiconductor lasers
Audience: Graduate

2. Construct analytical models to evaluate semiconductor laser performance
Audience: Graduate

3. Apply design tradeoffs to semiconductor laser design
Audience: Graduate

4. Determine the relationship between compound semiconductor material properties and semiconductor laser operation
Audience: Graduate

E C E 742 — COMPUTATIONAL METHODS IN ELECTROMAGNETICS
3 credits.

Computational techniques for solving differential and integral equations that govern static, frequency-domain, and time-domain electromagnetic field phenomena. Applications of the finite-difference time-domain method, finite-element method, and method of moments to practical electromagnetics engineering problems. Knowledge of high-level programming language like MATLAB strongly encouraged. Knowledge of electromagnetics [such as E C E 320] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E 743 – HIGH-POWER DIODE LASERS AND AMPLIFIERS
3 credits.

Single-mode diode lasers and amplifiers and their applications; an in-depth treatment of the four basic types of high-power coherent diodes: phase-locked arrays, master-oscillator power amplifiers, unstable resonators, and external-cavity-controlled resonators. Knowledge of electromagnetics [such as E C E 320] and solid-state electronics [such as E C E 335] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2020
Learning Outcomes: 1. Apply simulation tools to characterize the physical operation of high-power semiconductor lasers
Audience: Graduate

2. Construct analytical models to evaluate high-power semiconductor laser performance
Audience: Graduate

3. Apply design tradeoffs to high-power semiconductor laser and amplifier design
Audience: Graduate

4. Determine the photonic-crystal laser equivalence to phase-locked array of semiconductor lasers
Audience: Graduate

E C E 744 – THEORY OF MICROWAVE CIRCUITS AND DEVICES
3 credits.

Scattering matrices; symmetrical junctions; impedance and ABCD matrices; equivalent circuits. Wave propagation in periodic structures and anisotropic media; Floquet's theorem; Brillouin diagrams; Hartree harmonics; tensor permeability, conductivity, and permittivity; coupled wave equations; normal modes; applications in ferrite devices. Knowledge of advanced engineering electromagnetics [such as E C E 740] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2022

E C E 745 – SOLID STATE ELECTRONICS
3 credits.

Physical principles underlying the action of semiconductor devices, chemical bonding and energy band structure, Boltzmann transport theory, optical and high frequency effects, diffusion and drift, interfaces, properties of elemental and compound semiconductors.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

E C E/PHYSICS 746 – QUANTUM ELECTRONICS
3 credits.

Elementary aspects of Lagrange theory of fields and field quantization; Bose, Fermi and Pauli operators; interaction of fields; quantum theory of damping and fluctuations; applications to lasers, nonlinear optics, and quantum optics. Knowledge of lasers [such as PHYSICS 546] and graduate-level electromagnetics [such as E C E 740 or PHYSICS 721] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E 747 – NANOPHOTONICS
3 credits.

Optics/photonics at nanometer and micrometer length scales, including EM waves in dielectrics and metals, computational electromagnetics, waveguides and waveguide coupling, optical resonators, basic nanofabrication techniques, thin-film interference, surface-plasmon polaritons, localized surface-plasmon resonances, applications of plasmonics, super-resolution imaging, photonic crystals, composite materials and metamaterials, metasurfaces. Knowledge of Maxwell's equation and basic ray/wave optics, as would typically be obtained from junior-level or higher electromagnetics or optics courses [such as E C E 320 or E C E 434], is strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Demonstrate an understanding of electromagnetic waves in various media, at boundaries and interfaces, and in various types of waveguides
Audience: Graduate

2. Carry out a variety of two-dimensional (and, depending on the project, three-dimensional) simulations using the finite-difference time-domain method
Audience: Graduate

3. Recall, summarize, and evaluate basic nanofabrication concepts as they relate to nanophotonic structures
Audience: Graduate

4. Identify, formulate, and solve problems describing localized and propagating surface plasmons in various geometries
Audience: Graduate

5. Demonstrate awareness and understanding of various applications of nanophotonics and plasmonics, especially in the areas of sensing and biomedical applications
Audience: Graduate

6. Recall the similarities and differences between composite materials, metamaterials, metasurfaces, and related photonic structures
Audience: Graduate

E C E/PHYSICS 748 – LINEAR WAVES
3 credits.

General considerations of linear wave phenomena; one dimensional waves; two and three dimensional waves; wave equations with constant coefficients; inhomogenous media; random media. Lagrangian and Hamiltonian formulations; asymptotic methods. Knowledge of electromagnetics [such as E C E 320 or PHYSICS 321], mechanics [such as M E 340], or vibrations [such as M E 440] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

E C E/N E/PHYSICS 749 – COHERENT GENERATION AND PARTICLE BEAMS
3 credits.

Fundamental theory and recent advances in coherent radiation charged particle beam sources (microwave to X-ray wavelengths) including free electron lasers, wiggler/wave-particle dynamics, Cerenkov masers, gyrotrons, coherent gain and efficiency, spontaneous emission, beam sources and quality, related accelerator concepts experimental results and applications.
Requisites: E C E 740
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

E C E/COMP SCI 750 – REAL-TIME COMPUTING SYSTEMS
3 credits.

Introduction to the unique issues in the design and analysis of computer systems for real-time applications. Hardware and software support for guaranteeing timeliness with and without failures. Resource management, time-constrained communication, scheduling and imprecise computations, real-time kernels and case studies. Students are strongly encouraged to have knowledge of computer architecture (e.g., E C E/COMP SCI 552) and operating system functions (e.g., COMP SCI 537)
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2024

E C E 751 – EMBEDDED COMPUTING SYSTEMS
3 credits.

Embedded applications, embedded processors and multiprocessors, embedded system design and simulation, configurable/reconfigurable embedded systems, embedded compilers and tool chains, run-time systems, application design and customization, hardware and software co-design, low-power design. Knowledge of computer architecture [such as E C E 552] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2023

E C E/COMP SCI 752 — ADVANCED COMPUTER ARCHITECTURE I
3 credits.

Processor design, computer arithmetic, pipelining, multi-operation processors, vector processors, control units, precise interrupts, main memory, cache memories, instruction set design, stack machines, busses and I/O, protection and security. Students are strongly encouraged to have knowledge of computer architecture (e.g., E C E/COMP SCI 552).
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E 753 — FAULT-TOLERANT COMPUTING
3 credits.

Fault modeling, redundancy techniques and reliability evaluation, error detecting and correcting codes, self-checking circuits, fault diagnosis, software fault tolerance, and case studies. Knowledge of probability [such as E C E 431] and computer architecture [such as E C E/COMP SCI 552] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2023

E C E/COMP SCI 755 — VLSI SYSTEMS DESIGN
3 credits.

Overview of MOS devices and circuits; introduction to integrated circuit fabrication; topological design of data flow and control; interactive graphics layout; circuit simulation; system timing; organizational and architectural considerations; alternative implementation approaches; design project. E C E 555 or equivalent experience is strongly recommended.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E/COMP SCI 756 — COMPUTER-AIDED DESIGN FOR VLSI
3 credits.

Broad introduction to computer-aided design tools for VLSI, emphasizing implementation algorithms and data structures. Topics covered: design styles, layout editors, symbolic compaction, module generators, placement and routing, automatic synthesis, design-rule checking, circuit extraction, simulation and verification. Students are strongly encourage to have programming skills and to have taken a course in Digital System Fundamentals such as E C E/COMP SCI 352.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2023

E C E/COMP SCI 757 — ADVANCED COMPUTER ARCHITECTURE II
3 credits.

Parallel algorithms, principles of parallelism detection and vectorizing compilers, interconnection networks, MIMD machines, processor synchronization, data coherence, multis, dataflow machines, special purpose processors. Students are strongly encouraged to have knowledge of computer architecture (e.g., E C E/COMP SCI 552).
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E/COMP SCI/E M A/E P/M E 759 — HIGH PERFORMANCE COMPUTING FOR APPLICATIONS IN ENGINEERING
3 credits.

An overview of hardware and software solutions that enable the use of advanced computing in tackling computationally intensive Engineering problems. Hands-on learning promoted through programming assignments that leverage emerging hardware architectures and use parallel computing programming languages. Students are strongly encourage to have completed COMP SCI 367 or COMP SCI 400 or to have equivalent experience.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E/COMP SCI 760 – MACHINE LEARNING
3 credits.

Computational approaches to learning: including inductive inference, explanation-based learning, analogical learning, connectionism, and formal models. What it means to learn. Algorithms for learning. Comparison and evaluation of learning algorithms. Cognitive modeling and relevant psychological results.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Identify different aspects of machine learning, including supervised learning, unsupervised learning, and reinforcement learning
Audience: Graduate

2. Implement and analyze a variety of supervised models for classification and regression, including decision trees, instance-based models, naive Bayes, support vector machines, a variety of neural networks, linear and logistic regression, and others
Audience: Graduate

3. Implement and analyze neural network models, starting with the perceptron, and continuing to multilayer perceptrons, convolutional neural networks, recurrent neural networks, along with deep generative models
Audience: Graduate

4. Identify various types of regularization techniques and their properties
Audience: Graduate

5. Implement optimization techniques used in modern machine learning, including gradient descent and stochastic gradient descent
Audience: Graduate

6. Apply various concepts and metrics involved in evaluating models: accuracy, F measures, ROC, and precision/recall curves, and implement cross-validation
Audience: Graduate

7. Analyze unsupervised learning techniques for clustering, dimensionality reduction, and latent models
Audience: Graduate

8. Identify classical and modern techniques to improve models or deal with dearth of data: ensemble methods, semi-supervised learning, weak supervision
Audience: Graduate

E C E/COMP SCI 761 – MATHEMATICAL FOUNDATIONS OF MACHINE LEARNING
3 credits.

Mathematical foundations of machine learning theory and algorithms. Probabilistic, algebraic, and geometric models and representations of data, mathematical analysis of state-of-the-art learning algorithms and optimization methods, and applications of machine learning. Knowledge of probability [such as MATH/STAT 431 or COMP SCI/E C E 561] and linear algebra [such as MATH 341 or M E/COMP SCI/E C E 532] is required.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Derive and apply mathematical tools for machine learning from probability, statistics, linear algebra, and optimization
Audience: Graduate

2. Perform mathematical analysis and characterization of generative and discriminative models
Audience: Graduate

3. Perform mathematical analysis of machine learning algorithms
Audience: Graduate

4. Perform derivation of basic machine learning error bounds and related performance analysis
Audience: Graduate

5. Read and understand theoretical papers from machine learning conferences
Audience: Graduate

E C E/COMP SCI 766 — COMPUTER VISION
3 credits.

Fundamentals of image analysis and computer vision; image acquisition and geometry; image enhancement; recovery of physical scene characteristics; shape-from techniques; segmentation and perceptual organization; representation and description of two-dimensional objects; shape analysis; texture analysis; goal-directed and model-based systems; parallel algorithms and special-purpose architectures. Students are strongly encouraged to have basic proficiency in calculus and linear algebra, such as MATH 340, and basic programming such as COMP SCI 300.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2024
Learning Outcomes: 1. Develop basic computer vision applications using a programming environment
Audience: Graduate

2. Formulate computer vision research problems motivated from real-world applications
Audience: Graduate

3. Evaluate and compare existing solutions to a computer vision problem
Audience: Graduate

4. Design approaches for solving computer vision problems based on a broad range of fundamental concepts in 2D and 3D computer vision, sensing and recognition
Audience: Graduate

5. Communicate solutions verbally and in writing to justify choices while designing solutions
Audience: Graduate

E C E/CBE/MATH 777 — NONLINEAR DYNAMICS, BIFURCATIONS AND CHAOS
3 credits.

Advanced interdisciplinary introduction to qualitative and geometric methods for dissipative nonlinear dynamical systems. Local bifurcations of ordinary differential equations and maps. Chaotic attractors, horseshoes and detection of chaos.
Requisites: Graduate/professional standing or member of the Pre-Masters Mathematics (Visiting International) Program
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2016

E C E/B M E/MED PHYS 778 — MACHINE LEARNING IN ULTRASOUND IMAGING
3 credits.

Concepts and machine learning techniques for ultrasound beamforming for image formation and reconstruction to image analysis and interpretation will be presented. Key machine learning and deep learning concepts applied to beamforming, compressed sampling, speckle reduction, segmentation, photoacoustics, and elasticity imaging will be evaluated utilizing current peer-reviewed publications.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Critically read and evaluate peer-reviewed journal papers describing machine learning applications in ultrasound imaging.
Audience: Graduate

2. Apply, implement and expand upon ideas from these publications to applications in ultrasound imaging.
Audience: Graduate

3. Present the results of their critical evaluation and implementation to the class.
Audience: Graduate

4. Write a research paper based on their findings suitable for publication.
Audience: Graduate

E C E/COMP SCI 782 – ADVANCED COMPUTER SECURITY AND PRIVACY
3 credits.

Security and privacy issues in software, networks, and hardware systems. Security vulnerabilities, privacy threats, threats modeling, and mitigation strategies. Privacy issues related to user interaction with devices, online systems, and networks. In addition, a selection of more advanced topics will be covered. Possible examples include applied cryptography in the context of systems, security and privacy policies, user authentication, and cyber-physical systems. Builds on prior experiences with one or more of the following: networking, security, modern machine learning, embedded systems, and mobile computing.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Identify contemporary research problems related to the security and privacy of modern computer systems
Audience: Graduate

2. Implement known security attacks to identify weaknesses that led to those attacks and evaluate defense strategies
Audience: Graduate

3. Differentiate among the different dimensions involved in protecting users' security and privacy as they relate to effectiveness, practicality, and usability
Audience: Graduate

4. Analyze, interpret, and critique research papers from top-tier security conferences by identifying their strengths and weaknesses
Audience: Graduate

5. Propose original research by defining a problem, outlining a plan, performing the original research, and designing, implementing, and evaluating the proposed solution
Audience: Graduate

6. Work effectively in teams to complete a research project
Audience: Graduate

7. Communicate effectively through written reports, oral presentations, and discussion
Audience: Graduate

E C E 790 – MASTER'S RESEARCH
1-9 credits.

Independent work on master's research overseen by a qualified instructor.
Requisites: Declared in Electrical Engineering: Research, M.S. or Electrical Engineering: Power Engineering, M.S.
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025
Learning Outcomes: 1. Demonstrate an ability to formulate, analyze, and independently solve advanced engineering problems
Audience: Graduate

2. Communicate research results orally and in writing
Audience: Graduate

E C E 817 – NONLINEAR SYSTEMS
3 credits.

Modelling nonlinear systems, linearization, equilibria, solution concepts, phase plane analysis, stability concepts, Lyapunov methods, oscillations, vector space methods, control system nonlinearities and design. Selected topics from the following: input-output methods, switching and variable structure systems, feedback linearization, and Lyapunov robustness. Knowledge of linear systems [such as E C E 717] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2023

E C E 821 – OPTIMAL CONTROL AND VARIATIONAL METHODS
3 credits.

Variational principles in optimization and optimal control, constrained control and reachability analysis, stability of optimal control, data-driven methods for optimal control. Knowledge of linear systems [such as E C E 717] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2024
Learning Outcomes: 1. Identify appropriate notions of optimality for controls in autonomous systems
Audience: Graduate

2. Formulate optimal control problems in a rigorous mathematical framework
Audience: Graduate

3. Use systematic design procedures for optimal controls
Audience: Graduate

4. Use data driven optimal control for dynamical systems
Audience: Graduate

E C E 826 – THEORETICAL FOUNDATIONS OF LARGE-SCALE MACHINE LEARNING
3 credits.

Mathematical foundations of large-scale machine learning and optimization. Focus on recent texts in machine learning, optimization, and randomized algorithms, focused on tradeoffs that are driving algorithmic design in this new discipline. These trade-offs revolve around speed of convergence, statistical accuracy, robustness, scalability, algorithmic complexity, and implementation.
Requisites: COMP SCI/E C E 761
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2024
Learning Outcomes: 1. Prove convergence rates for stochastic optimization algorithms
Audience: Graduate

2. Describe systems tradeoffs that drive algorithmic design in large-scale machine learning
Audience: Graduate

3. Summarize recent literature in large-scale optimization and machine learning
Audience: Graduate

4. Design, tune, or tailor a given machine learning algorithm for a new system
Audience: Graduate

5. Evaluate statements about parallelizability, generalization, convergence of optimization algorithms
Audience: Graduate

E C E 830 – ESTIMATION AND DECISION THEORY
3 credits.

Estimation and decision theory applied to random processes and signals in noise: Bayesian, maximum likelihood, and least squares estimation; the Kalman filter; maximum likelihood and maximum aposteriori detection; adaptive receivers for channels with unknown parameters or dispersive, fading characteristics; the RAKE receiver; detection systems with learning features.
Requisites: E C E 730
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2019

E C E 835 – LIGHT INTERACTIONS WITH QUANTUM MATERIALS
3 credits.

Light-matter interactions with quantum systems and their applications in quantum computing, communications, and sensing. Brief review of quantum mechanics and derivation of quantum structure of atoms. Deeper exploration of concepts and applications of quantum optics (such as use of nonclassical light, entangled photons) and experimental techniques on how to control and measure quantum systems with photons (including atom cooling and trapping, coherent interactions, putting atoms in cavities). Knowledge of introductory-level classical electromagnetism (such as E C E 220 or PHYSICS 202) and modern physics (such as PHYSICS/E C E 235 or PHYSICS 241) required.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Explain concepts in the interactions of light with quantum systems, such as absorption and emission processes, Rabi oscillations, and cavity quantum electrodynamics
Audience: Graduate

2. Formulate techniques to prepare, manipulate, and detect quantum states using common light sources and optical components
Audience: Graduate

3. Apply numerical methods to model and analyze interactions in quantum systems
Audience: Graduate

4. Identify critical differences between classical and non-classical light sources and recognize experimental approaches to generate, characterize, and utilize these light sources in quantum measurements
Audience: Graduate

5. Analyze and effectively communicate the use of atom-photon interactions in state-of-the-art quantum computing, communication, and sensing experiments
Audience: Graduate

E C E 841 – ANTENNAS
3 credits.

Applications of Maxwell's field equations to radiation problems; transmission of radio waves; radiation and impedance characteristics of various antennas and arrays. Analysis of complete antenna systems.
Requisites: E C E 740
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Perform wireless system analysis, including link budget calculation for wireless communications and radar systems
Audience: Graduate

2. Use Maxwell's equations to solve basic radiation problems from electric and magnetic current distributions in space
Audience: Graduate

3. Analyze and design basic types of wire antennas, including dipole and loop antennas, and aperture antennas, including horn, reflector, patch, slot, lens, and reflectarray antennas
Audience: Graduate

4. Analyze and design basic types of antenna arrays, including linear and planar arrays
Audience: Graduate

5. Synthesize antennas and antenna arrays to achieve a given desired radiation pattern in the far field
Audience: Graduate

6. Demonstrate a fundamental understanding of antenna measurement techniques including common techniques used to measure the radiation pattern, gain, directivity, polarization, and bandwidth of an antenna under test
Audience: Graduate

7. Determine a suitable antenna to use for a given application from the system level performance metrics desired including, bandwidth, gain, radiation pattern, frequency of operation, etc.
Audience: Graduate

E C E/MATH 842 – TOPICS IN APPLIED ALGEBRA
3 credits.

Applied topics with emhasis on algebraic constructions and structures. Examples include: algebraic coding theory; codes (algebraic-geometric, convolutional, low-density-parity-check, space-time); curve and lattice based cryptography; watermarking; computer vision (face recognition, multiview geometry).
Requisites: Graduate/professional standing or member of the Pre-Masters Mathematics (Visiting International) Program
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

E C E 845 – TRANSPORT IN SEMICONDUCTOR DEVICES
3 credits.

Transport of carriers in electronic devices, starting from the Boltzmann equation and the quantum mechanical treatment of scattering, and covering applications to devices; transport in 2D structures; modeling of transport; experiments and devices involving hot electrons.
Requisites: E C E 745
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E C E/PHYSICS 848 – NONLINEAR WAVES
3 credits.

General considerations of nonlinear wave phenomena; nonlinear hyperbolic waves; nonlinear dispersion; nonlinear geometrical optics; Whitham's variational theory; nonlinear and parametric instabilities; solitary waves; inverse scattering method. Knowledge of electromagnetics [such as E C E 320 or PHYSICS 321] or mechanics [such as M E 340] encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2019

E C E/COMP SCI/STAT 861 – THEORETICAL FOUNDATIONS OF MACHINE LEARNING
3 credits.

Advanced mathematical theory and methods of machine learning. Statistical learning theory, Vapnik-Chevronenkis Theory, model selection, high-dimensional models, nonparametric methods, probabilistic analysis, optimization, learning paradigms.
Requisites: E C E/COMP SCI 761 or E C E 830
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

E C E/MATH/STAT 888 – TOPICS IN MATHEMATICAL DATA SCIENCE
1-3 credits.

Advanced topics in the mathematical foundations of data science
Requisites: Graduate/professional standing or member of the Pre-Masters Mathematics (Visiting International) Program
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025
Learning Outcomes: 1. Apply advanced mathematical concepts to solve a variety of data science problems
Audience: Graduate

2. Analyze rigorously the mathematical properties of methods used in data science
Audience: Graduate

E C E 890 – PRE-DISSERTATOR'S RESEARCH
1-9 credits.

Independent work on doctoral research overseen by a qualified instructor.
Requisites: Declared in Electrical Engineering PhD
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025
Learning Outcomes: 1. Demonstrate an ability to formulate, analyze, and independently solve advanced engineering problems
Audience: Graduate

2. Communicate research results in writing and seminars
Audience: Graduate

E C E 901 – SPECIAL TOPICS IN ELECTRICAL AND COMPUTER ENGINEERING
1-3 credits.

Special advanced topics across Electrical and Computer Engineering. The topics covered, instructors, and prerequisites all vary with semester and with section. Particular topics typically reflect state-of-the-art ideas and research.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

E C E/N E/PHYSICS 922 – SEMINAR IN PLASMA PHYSICS
0-1 credits.

Current topics in plasma physics.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

E C E 990 – DISSERTATOR'S RESEARCH
1-12 credits.

Independent work on dissertation overseen by a qualified instructor.
Requisites: Declared in Electrical Engineering PhD
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025
Learning Outcomes: 1. Demonstrate an ability to formulate, analyze, and independently solve advanced engineering problems
Audience: Graduate

2. Communicate research results in writing and seminars
Audience: Graduate

E C E 999 – ADVANCED INDEPENDENT STUDY
1-3 credits.

Directed study projects as arranged with instructor.
Requisites: Consent of instructor
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025