

Electrical and Computer Engineering (ECE)

ECE 302, 402 Introduction to Electrical Engineering 3-4 Hours

Examine the scope and nature of professional activities of electrical engineers, including problem-solving techniques; analysis and design methods; engineering professional ethics; analysis of analog resistive circuits, including Thevenin/Norton equivalents, mesh analysis, and nodal analysis; and operational amplifiers (DC response).

ECE 302H, 402H Introduction to Electrical Engineering: Honors 3-4 Hours

Examine the scope and nature of professional activities of electrical engineers, including problem-solving techniques; analysis and design methods; engineering professional ethics; analysis of linear and non-linear analog circuits, including Thevenin/Norton equivalents, two-port networks, frequency domain analysis, mesh analysis, and nodal analysis; and operational amplifiers (DC response).

ECE 306, 406 Introduction to Computing 3-4 Hours

Introduction to computing including bits and operations on bits, number formats, arithmetic and logic operations, and digital logic. Explore the Von Neumann model of processing including memory, arithmetic logic unit, registers, and instruction decoding and execution. Examine structured programming and debugging, machine and assembly language programming, the structure of an assembler, physical input/output through device registers, subroutine call/return; trap instruction, stacks and applications of stacks.

ECE 306H, 406H Introduction to Computing: Honors 3-4 Hours

Introduction to computing including bits and operations on bits, number formats, arithmetic and logic operations, and digital logic. Explore the Von Neumann model of processing including memory, arithmetic logic unit, registers, and instruction decoding and execution. Examine structured programming and debugging, machine and assembly language programming, the structure of an assembler, physical input/output through device registers, subroutine call/return; trap instruction, stacks and applications of stacks.

ECE 307E Elements of Electrical and Computer Engineering 3 Hours

Introduction to electrical engineering: direct current circuit analysis, resistors, LEDs, switches, current and voltage measurements. Introduction to computer engineering: number systems, digital logic, storage, finite state machines, programming basics, microcontrollers.

ECE 107H Engineering Leadership: Honors 1 Hour

Explore different research areas in electrical and computer engineering and participate in community service projects within the discipline.

ECE 108S Topics in Technical Skills 1 Hour

Explore the development of a specific technical skill.

ECE 109K, 209K, 309K, 409K Topics in Electrical Engineering 1-4 Hours

ECE 209P Introduction to Professional Engineering 2 Hours

Explore professional skills including academic success, career development, and engineering ethics.

ECE 309S Development of a Solar-Powered Vehicle 3 Hours

Analyze, design, and construct a solar-powered car for national competitions involving other universities. Study electrical, mechanical, and aerodynamic systems.

ECE 411 Circuit Theory 4 Hours

Examine capacitance and inductance; first- and second-order transient circuit response, including operational amplifier circuits; sinusoidal steady state analysis; Bode plots; complex power in single and balanced three-phase systems; transformers; two-port networks (Z-parameters and Y-parameters); and computer-aided analysis and design.

ECE 411H Circuit Theory: Honors 4 Hours

Examine capacitance and inductance; first- and second-order transient circuit response, including operational amplifier circuits; sinusoidal steady state analysis; Bode plots; complex power in single and balanced three-phase systems; transformers; two-port networks (Z-parameters and Y-parameters); and computer-aided analysis and design.

ECE 111S Tools to Enhance Academic Success 1 Hour

Explore the components necessary to enhance academic success in engineering coursework including academic self-regulation, time management, self-discipline, goal-setting, weekly and semester planning, growth mindset, self-motivation, management of anxiety and stress, learning and memory, learning strategies, retrieval practices, and exam preparation.

ECE 312, 412 Software Design and Implementation I 3-4 Hours

Explore basic problem solving, design and implementation techniques for imperative programming; structured programming in the C/C++ language; programming idioms. Examine software design principles, including modularity, coupling and cohesion; software engineering tools; elementary data structures; and asymptotic analysis.

ECE 312H, 412H Software Design and Implementation I: Honors 3-4 Hours

Explore basic problem solving, design and implementation techniques for imperative programming; structured programming in the C/C++ language; programming idioms. Examine software design principles, including modularity, coupling and cohesion; software engineering tools; elementary data structures; and asymptotic analysis.

ECE 313 Linear Systems and Signals 3 Hours

Examine representation of signals and systems; system properties; sampling; Laplace and z-transforms; transfer functions and frequency response; convolution; stability; Fourier transform; feedback; and control applications. Explore computer analysis using MATLAB or Python.

ECE 313H Linear Systems and Signals: Honors 3 Hours

Examine representation of signals and systems; system properties; sampling; Laplace and z-transforms; transfer functions and frequency response; convolution; stability; Fourier transform; feedback; and control applications. Explore computer analysis using MATLAB or Python.

ECE 316 Digital Logic Design 3 Hours

Explore boolean algebra; analysis and design of combinational and sequential logic circuits; state machine design and state tables and graphs; simulation of combinational and sequential circuits; applications to computer design; and hardware description languages (HDLs) and field-programmable gate arrays (FPGAs).

ECE 319H, 419H Introduction to Embedded Systems: Honors 3-4 Hours

Examine embedded systems; machine language execution; assembly and C language programming; local variables and subroutines; input/output synchronization; analog to digital conversion and digital to analog conversion; debugging; and interrupts.

ECE 319K, 419K Introduction to Embedded Systems 3-4 Hours

Explore embedded systems; machine language execution; assembly and C language programming; local variables and subroutines; input/output synchronization; analog to digital conversion and digital to analog conversion; debugging; and interrupts.

ECE 119S, 219S, 319S, 419S, 519S, 619S, 719S, 819S, 919S Topics in Electrical and Computer Engineering 1-9 Hours
Used to record credit the student earns while enrolled at another institution in a program administered by the University's Study Abroad Office. Credit is recorded as assigned by the study abroad advisor in the Department of Electrical and Computer Engineering. University credit is awarded for work in an exchange program; it may be counted as coursework taken in residence. Transfer credit is awarded for work in an affiliated studies program.

ECE 321K Mixed Signal and Circuits Laboratory 3 Hours
Explore digital and analog parametric testing of mixed-signal circuits and systems, including frequency response, harmonic and intermodulation, and noise behavior; use of system-level test equipment, including network analyzers, spectrum analyzers, and probe stations; coherent versus noncoherent measurements; and design for testability.

ECE 422C Software Design and Implementation II 4 Hours
Explore methods for engineering software with a focus on abstraction; specification, design, implementation, and testing of object-oriented code using a modern development tool-set for complex systems; design and implementation of object-oriented programs in Java; abstract data types; inheritance; polymorphism; parameterized types and generic programming; the operation and application of commonly used data structures; exception handling and fault tolerance; algorithm analysis; and teamwork models.

ECE 325 Electromagnetic Engineering 3 Hours
Examine electrostatics and magnetostatics; properties of conductive, dielectric, and magnetic materials; solutions of Maxwell's equations; uniform plane wave applications; and frequency- and time-domain analyses of transmission lines.

ECE 325K Antennas and Wireless Propagation 3 Hours
Explore solutions of time-varying Maxwell's equations with applications to antennas and wireless propagation; antenna theory and design, array synthesis; electromagnetic wave propagation, scattering, and diffraction; and numerical methods for solving Maxwell's equations.

ECE 125S Internship in Electrical and Computer Engineering 1 Hour
Practical work experience in industry or a research lab under the supervision of an engineer or scientist. Requires a substantial final report.

ECE 129S, 229S, 329S, 429S, 529S, 629S, 729S, 829S, 929S Topics in Electrical and Computer Engineering 1-9 Hours
This course is used to record credit the student earns while enrolled at another institution in a program administered by the University's Study Abroad Office. Credit is recorded as assigned by the study abroad adviser in the Department of Electrical and Computer Engineering. University credit is awarded for work in an exchange program; it may be counted as coursework taken in residence. Transfer credit is awarded for work in an affiliated studies program.

ECE 331 Electrical Circuits, Electronics, and Machinery 3 Hours
Explore brief theory of direct and alternating current circuits; single-phase and three-phase power transmission; electronic devices and instrumentation; and electromechanics.

ECE 333T Engineering Communication 3 Hours
Explore advanced engineering communication skills, with emphasis on technical documents, oral reports, and graphics. Participate in collaborative work involving online communication and research.

ECE 334K Quantum Theory of Electronic Materials 3 Hours
Introduction to quantum mechanics; atoms and molecules; electron statistics; quantum theory of solids; electronic phenomena in semiconductors; and device applications based on these phenomena.

ECE 334M Magnetic Materials and Devices 3 Hours
Explore the fundamentals and applications of magnetic materials, in particular to nano-devices; examine the origin of magnetism in oxides and metals; magnetic switching mechanisms, and how spin structures arise such as domain walls and topologically-protected spin states; discuss applications to future computing nano-devices.

ECE 438 Fundamentals of Electronic Circuits I Laboratory 4 Hours
Explore the analysis and design of electronic circuits using semiconductor devices. Examine basic device physics and small-signal modeling for diodes, bipolar junction transistors, and metal-oxide-semiconductor transistors; operation region and biasing; basic switching circuits; single-stage and multi-stage amplifier design and analysis; input and output impedance characteristics of amplifiers; frequency response; AC and DC coupling techniques; and differential amplifiers and output stages.

ECE 438K Analog Electronics 4 Hours
Explore the analysis and design of analog electronic circuits; transistor models; single-ended amplifiers; differential amplifiers; operational amplifiers; frequency response; feedback theory; stability analysis; circuit nonidealities; op-amp-based circuits; output stages; power amplifiers; passive and active analog filters; and relaxation oscillators

ECE 338L Analog Integrated Circuit Design 3 Hours
Explore the analysis and design of analog integrated circuits; transistor models; simple and advanced current mirrors; single-ended amplifiers; differential amplifiers; operational amplifiers; frequency response; feedback theory; stability analysis; circuit nonidealities and noise; output stages; and analog filters. Examine computer-aided design (CAD) tools for circuit analysis and design.

ECE 339 Solid-State Electronic Devices 3 Hours
Examine semiconductor materials; atomic orbitals to energy band structure of semiconductors; charge carrier transport, electron-hole generation and recombination; p-n junctions and Schottky barriers; bipolar and field-effect transistors; and optoelectronic devices.

ECE 339S Solar Energy Conversion Devices 3 Hours
Investigate basic principles of photovoltaic devices which convert light into charge carriers (electrons and holes). Examine electrons and holes in semiconductors, generation and recombination, junctions, analysis of the p-n junction, silicon and III-V semiconductor solar cell design and optimization, thin film solar cell technologies, managing light, strategies for higher efficiency, and a brief overview of non-photovoltaic approaches to solar energy conversion.

ECE 440 Integrated Circuit Nanomanufacturing Techniques 4 Hours
Examine integrated circuit processing; crystal growth and wafer preparation; epitaxial growth; oxidation, diffusion, and ion implantation; thin-film deposition techniques; and lithography and etching.

ECE 340P High-Throughput Nanopatterning 3 Hours
Explore sub-50nm fabrication using mechanical patterning techniques; overview of photolithography, mechanical nanopatterning processes, hot embossing, and UV imprint lithography; wafer-scale and roll-to-roll nanopatterning with applications in electronics, photonics, and nanomedicine; physics of nanoreplication, process limits, template (mold) fabrication, defect mechanisms, and factors affecting throughput.

ECE 341 Electric Drives and Machines 3 Hours
Explore fundamentals of electric machines. Examine electromechanical energy conversion; magnetic circuits, transformers, and energy conversion devices; and power electronics. Discuss motor drive fundamentals and applications.

ECE 445L Embedded Systems Design Laboratory 4 Hours

Explore the design of microcontroller-based embedded systems; interfacing from both a hardware and software perspective; and applications, including audio, data acquisition, and communication systems.

ECE 445M Embedded and Real-Time Systems Laboratory 4 Hours

Explore real-time operating systems; implementation of context switching, threads, multitasking, real-time scheduling, synchronization, communication, storage, file systems, memory management, process linking and loading, hardware interfacing, and networking; debugging and testing; operating system performance, including latency, jitter, deadlines, deadlocks, and starvation; real-time systems, including data acquisition, sensing, actuating, digital control, signal processing, and robotics.

ECE 445S Real-Time Digital Signal Processing Laboratory 4 Hours

Explore digital signal processing algorithms; simulation and real-time implementation of audio and communication systems; filters; pulse shaping and matched filters; modulation and demodulation; adaptive filters; carrier recovery; symbol synchronization; equalization; quantization; and data conversion.

ECE 347 Modern Optics 3 Hours

Explore modern optical wave phenomena with applications to imaging, holography, fiber optics, lasers, and optical information processing.

ECE 348 Laser and Optical Engineering 3 Hours

Explore principles of operation and applications of lasers, optical modulators, and optical detectors.

ECE 351H Probability and Random Processes: Honors 3 Hours

Examine probability, random variables, statistics, and random processes, including counting, independence, conditioning, expectation, density functions, distributions, law of large numbers, central limit theorem, confidence intervals, hypothesis testing, statistical estimation, stationary processes, Markov chains, and ergodicity.

ECE 351K Probability and Random Processes 3 Hours

Examine probability, random variables, statistics, and random processes, including counting, independence, conditioning, expectation, density functions, distributions, law of large numbers, central limit theorem, confidence intervals, hypothesis testing, statistical estimation, stationary processes, Markov chains, and ergodicity.

ECE 351M Digital Signal Processing 3 Hours

Explore sampling, aliasing, truncation effects; discrete and fast Fourier transform methods; convolution and deconvolution; finite and infinite impulse response filter design methods; Wiener, Kalman, noncausal, linear phase, median, and prediction filters; and spectral estimation.

ECE 155 Electrical and Computer Engineering Seminar 1 Hour

Hear presentations by speakers from industry, government, academia, and professional private practice. Explore environmental and other ethical concerns, safety awareness, quality management, technical career descriptions, and professionalism with a focus on engineering communication.

ECE 155L Engineering Leadership Seminar 1 Hour

Hear presentations by speakers from industry, government, academia, and professional private practice. Explore environmental and other ethical concerns, safety awareness, quality management, technical career descriptions, and professionalism.

ECE 155R Undergraduate Research Seminar 1 Hour

Explore areas of research in electrical and computer engineering.

ECE 160, 260, 360, 460 Special Problems in Electrical and Computer Engineering 1-4 Hours

Investigate special problems as approved by the electrical and computer engineering department.

ECE 360C Algorithms 3 Hours

Explore advanced problem-solving methods; algorithm design principles; complexity analysis; the study of the nature, impact, and handling of intractability; and the study of common algorithmic classes and their applications.

ECE 360F Introduction to Software Engineering 3 Hours

Introduction to the discipline of software engineering. Explore software system creation and evolution; fundamental concepts and principles of software product and software process systems, including requirements, architecture and design, construction, deployment, and maintenance; and documentation and document management, measurement and evaluation, software evolution, teamwork, and project management.

ECE 360G Programming Paradigms 3 Hours

Study programming language constructs, scripting languages, object-oriented languages, functional languages, language semantics, software engineering design, and design patterns.

ECE 460J Data Science Laboratory 4 Hours

Explore predictive modeling, regression and classification, data cleaning and preprocessing, feature engineering, unsupervised methods, principal component analysis, data clustering, model selection and feature selection, entropy and information theory, neural networks, deep learning, and machine learning for signals and time-series data.

ECE 360K Introduction to Digital Communications 3 Hours

Examine characterization of baseband and passband communication signals and channels, digital modulation, and pulse shaping; optimum receivers in additive white Gaussian noise including matched-filtering, machine learning (ML), and mean average precision (mAP) detection and their bit error probability for M-ary modulation; inter-symbol interference channels, finite impulse response (FIR) and infinite impulse response (IIR) equalization, multicarrier modulation, orthogonal frequency-division multiplexing (OFDM) and frequency domain equalization. Introduction to information theory, channel capacity, error control codes, and ML sequence detection (Viterbi decoding). Explore applications to stationary wireless and wireline channels.

ECE 460M Digital Systems Design Using Hardware Description Languages 4 Hours

Explore organization, design, simulation, synthesis, and testing of digital systems; hardware description languages (HDLs); field programmable gate arrays (FPGAs); hardware implementation of arithmetic and other algorithmic processes; state machine charts; microprogramming; and microprocessor design.

ECE 460N Computer Architecture 4 Hours

Examine characteristics of instruction set architecture and microarchitecture; physical and virtual memory; caches and cache design; interrupts and exceptions; integer and floating-point arithmetic; I/O processing; buses; pipelining, out-of-order execution, branch prediction, and other performance enhancements; design trade-offs; and case studies of commercial microprocessors. Explore behavioral-level design of a microarchitecture in a laboratory setting.

ECE 360P Concurrent and Distributed Systems 3 Hours

Investigate concurrency, lock-based and lock-free synchronization, resource allocation, multi-threaded programming, distributed systems programming, mutual exclusion, global snapshots, global property evaluation, message ordering, consensus, Byzantine agreement, and commit protocols.

ECE 460R Introduction to VLSI Design 4 Hours

Explore theory and practice of very-large-scale integration (VLSI) circuit design. Examine metal-oxide-semiconductor (MOS) transistors; static and dynamic complementary metal-oxide-semiconductor (CMOS) combinational and sequential circuits; design of adders, multipliers, and shifters; performance, power consumption and testing. Use computer-aided design (CAD) tools for layout, timing analysis, synthesis, physical design, and verification.

ECE 360S Digital Integrated Circuit Design 3 Hours

Examine circuit-level aspects of metal oxide silicon (MOS) and bipolar integrated circuit technologies. Explore logic gates and latches; propagation delays; and circuit simulation models.

ECE 360T Software Testing 3 Hours

Explore basic concepts and techniques used in testing software and finding bugs. Examine process, unit, integration, and system testing; manual and automatic techniques for generation of test inputs and validation of test outputs; and coverage criteria. Focus on functional testing.

ECE 361C Multicore Computing 3 Hours

Explore theoretical and practical aspects of designing multicore software systems; programming constructs for concurrent computation; openMP; sequential consistency; linearizability; lock-based synchronization; lock-free synchronization; wait-free synchronization; consensus number; software transactional memory; testing and debugging parallel programs; race detection; concurrent data structures such as stacks, queues, linked lists, hash tables, and skiplists; formal models; temporal logic; reachability analysis; and parallel graph algorithms.

ECE 361D System Design Metrics 3 Hours

Examine engineering design, manufacturing, and lifetime support issues; implications of customer perceptions of quality on design; economics of design; and legal implications of design decisions.

ECE 361E Machine Learning and Data Analytics for Edge Artificial Intelligence 3 Hours

Examine edge computing; Internet-of-Things (IoT); cyber-physical systems; energy-aware machine learning (ML); deep learning; model compression; knowledge distillation; federated learning; ML security; system optimization; model-architecture co-design; object detection; and social sensing.

ECE 361G Engineering Program Analysis 3 Hours

Explore program analysis; compilers; interpreters; code instrumentation; control-flow analysis; data-flow analysis; static single assignment form; dependency analysis; incremental analysis; autotuning; and just-in-time compilation.

ECE 461L Software Engineering and Design Laboratory 4 Hours

Examine generation of concrete software engineering artifacts at all stages of the software life-cycle processes; stakeholder needs to system requirements mapping; object-oriented design and analysis; and test driven development. Study design principles and methods; design and modeling tools; collaborative development environment; design patterns and refactoring; integration and testing tools. Examine emerging concepts in cloud native devops, including microservices, containers, and application programming interfaces (APIs). Explore design and development of at-scale software system using modern software development techniques, including re-usable front-end and back-end components, and cloud deployment.

ECE 361M Software Architectures 3 Hours

Explore the definitions, motivations, and utility of software system architectures from a technical and business perspective; derivation, specification, and analysis of architectural views in support of different phases in the system engineering lifecycle; methods to judge architectural quality; and communication of architectural views to a wide range of system stakeholders.

ECE 361N Information Security and Privacy 3 Hours

Explore information valuation; information classification; information confidentiality, integrity and availability; access control models; trusted identity, trust frameworks. Examine cryptology, designing information system security and privacy, threats and vulnerabilities. Introduction to network, software, and web security; risk assessments; data breach incident response; privacy laws and regulations.

ECE 461P Data Science Principles 4 Hours

Examine principles of unsupervised and supervised learning; exploratory data analysis; feature engineering; predictive modeling for regression and classification; clustering algorithms; neural networks and stochastic gradient descent methods; scalable models for Big Data sets; case studies; and programming predictive models in Python and R.

ECE 361Q Requirements Engineering 3 Hours

Explore the methods and technology for acquiring, representing, documenting, verifying, validating, and maintaining requirements; text-based, graphic-based, and computational requirements model representations; requirements analysis to synthesize and resolve conflicts among disparate stakeholder viewpoints; requirements traceability and evolution; and change management.

ECE 361R Radio-Frequency Electronics 3 Hours

Examine modeling of active and passive devices and transmission line structures at high frequencies. Explore analysis and design of radio-frequency electronic circuits including amplifiers, mixers, multipliers, detectors, and oscillators; transistor-, circuit-, and system-level design methods, challenges, and topologies; noise and distortion analysis; and evaluation of modern radio systems.

ECE 461S Operating Systems 4 Hours

Introduction to operating system design and implementation; the shell; process management and system calls; memory management; thread management, scheduling, synchronization and concurrency; file systems; input/output systems; virtual machines; and networking and security.

ECE 461T Compilers 4 Hours

Explore program compilation and translation from high-level into machine languages; compiler structure; syntax analysis; semantic analysis; type systems; code generation; intermediate language and representation; control and data flow analysis; and optimization techniques.

ECE 362G Smart Grids 3 Hours

Explore the fundamentals of smart electric power grids; smart grid architecture, communications, measurement, sensing, design, performance, standards and cyber security; distributed energy, renewable sources, and energy storage; and interoperability.

ECE 362K Introduction to Automatic Control 3 Hours

Explore analysis of linear automatic control systems in time and frequency domains; stability analysis; state variable analysis of continuous-time and discrete-time systems; root locus; Nyquist diagrams; Bode plots; sensitivity; and lead and lag compensation.

ECE 462L Power Electronics Laboratory 4 Hours

Explore the analysis, design, and operation of power electronic circuits; power conversion from AC to DC, DC to DC, and DC to AC; rectifiers, inverters, and pulse width modulated motor drives. Examine the use of energy from renewable sources such as photovoltaics and wind in a laboratory setting.

ECE 362M Power Electronics II 3 Hours

Examine pulse-width-modulated power converters, rigorous physical design and device selection, gate driving, thermal design, magnetics design, small-signal modeling and control, and EMI filtering. Explore design and prototyping.

ECE 362Q Power Quality and Harmonics 3 Hours

Examine and analyze power quality and harmonic phenomena in electric power systems, including characteristics and definitions, voltage sags, electrical transients, harmonics, mitigation techniques, and standards of power quality and harmonics.

ECE 362R Renewable Energy and Power Systems 3 Hours

Examine renewable energy sources and their integration into power systems. Explore wind energy: resources, turbines, blades, rotor power characteristics, generators, active and reactive power, variability, and voltage regulation; solar energy: resources, solar radiation measurements, photovoltaic materials and properties, photovoltaic electrical characteristics, and system integration; and demonstrations with commercial-grade solar panels and laboratory-scale wind turbines.

ECE 362S Development of a Solar-Powered Vehicle 3 Hours

Analyze, design, and construct a solar-powered car for national competitions involving other universities. Study electrical, mechanical, and aerodynamic systems.

ECE 363M Microwave and Radio Frequency Engineering 3 Hours

Examine design principles in microwave and radio frequency systems; transmission lines and waveguides; S-parameter representation; impedance matching; microwave network analysis; microwave devices and components; and electromagnetic effects in high-speed and high-frequency applications.

ECE 363N Engineering Acoustics 3 Hours

Principles of acoustics, with applications drawn from audio engineering, biomedical ultrasound, industrial acoustics, noise control, room acoustics, and underwater sound.

ECE 464C Corporate Senior Design Project 4 Hours

Undertake design and experimental projects in the laboratories of local companies. Examine the ethics of design for safety and reliability. Designed for electrical engineering students working full-time in the industry.

ECE 364D Introduction to Engineering Design 3 Hours

Introduction to the engineering design process. Explore the assessment and documentation of engineering problems and customer needs, such as acquiring, documenting, and verifying requirements; high-level system design principles; effects of economic, environmental, ethical, safety, and social issues in design; writing and presenting design specifications; and effective teamwork.

ECE 364E Interdisciplinary Entrepreneurship 3 Hours

Start a company with a team. Explore skill development and mentoring in start-up formation, technology development, market validation, marketing, sales, operations, human resources, program management, and finance. Discuss the role of intellectual property and the social issues in design, as well as ethical and safety considerations.

ECE 464G Multidisciplinary Senior Design Project 4 Hours

Undertake design and experimental projects with teams from multiple engineering disciplines. Examine the ethics of design for safety and reliability.

ECE 464H Honors Senior Design Project 4 Hours

Implement the previously developed engineering system design, including design review, prototyping, project testing and any subsequent design modifications; addressing economic, environmental, ethical, safety, and social issues; documentation of each of the preceding and publicly presenting design results; and working effectively in teams.

ECE 464K Senior Design Project 4 Hours

Implement the previously developed engineering system design, including design review, prototyping, project testing and any subsequent design modifications; addressing economic, environmental, ethical, safety, and social issues; documentation of each of the preceding and publicly presenting design results; and working effectively in teams.

ECE 464R Research Senior Design Project 4 Hours

Implement the previously developed engineering system design, including design review, prototyping, project testing and any subsequent design modifications; addressing economic, environmental, ethical, safety, and social issues; documentation of each of the preceding and publicly presenting design results; and working effectively in teams.

ECE 464S Start-Up Senior Design Project 4 Hours

Complete a practical engineering product design; validate the design through prototype construction and testing, modeling and simulation, and manufacturability analysis. Develop a completed company prospectus and seek venture funding for the project.

ECE 366 Engineering Economics I 3 Hours

Explore business organization; discounted cash flow calculations, including present-worth and rate-of-return calculations; replacement analyses; financial analyses; accounting and depreciation; income taxes; inflation; risk analysis, utility theory, decision models, sequential decision making; and value of information.

ECE 366K Engineering Economics II 3 Hours

Explore the fundamentals of risk management, including portfolio theory, capital asset pricing theory, and optimal project mix; hedging financial risk; advanced economic analysis of alternative energy systems; and advanced mathematical modeling techniques for economic analysis.

ECE 366L Statistics for Manufacturing 3 Hours

Explore statistical analysis applied to the development and control of manufacturing operations. Examine quality control, statistical process control, and design of experiments.

ECE 368L, 468L Power Systems Apparatus and Laboratory 3-4 Hours

Explore fundamentals of power systems emphasized through laboratory experiments; complex power, three-phase circuits, per-unit system, transformers, synchronous machines, transmission line models, steady-state analysis, induction machines, capacitor banks, protective relaying, surge arrestors, and instrumentation.

ECE 369 Power Systems Engineering 3 Hours

Examine power systems engineering. Explore complex power, phasors, balanced three phase power systems, transformers and per-unit systems, transmission line parameters, steady state operation of transmission lines, the power flow problem, symmetrical faults, power system controls, economic operation of power systems, optimal power flow, and deregulation and restructuring of electricity markets.

ECE 369L Relay Protection of Power Systems 3 Hours

Examine the theory, principles, and practices for protecting medium-voltage industrial power systems and high-voltage transmission grids, including symmetrical components; fault calculations and grounding; protection of motors, generators, cables, and transmission lines; and relay settings, fusing, and coordination of multiple protection devices.

ECE 370 Automatic Control II 3 Hours

Introduction to modern control theory, nonlinear and optimal control systems; controllability, observability, stability; state feedback, observers, eigenvalue assignment.

ECE 370K Computer Control Systems 3 Hours

Explore the analysis and design of linear discrete time control systems; z-transform theory; modified z-transforms; stability; multirate systems; digital simulation of discrete time systems; and synthesis of algorithms for computer controllers.

ECE 370L Introduction to Manufacturing Systems Automation 3 Hours

Explore applications of automation techniques to manufacturing systems, robotics, and computer vision.

ECE 370N Introduction to Robotics and Mechatronics 3 Hours
Examine structures for industrial robots; geometry and transformation; direct and inverse kinematics; differential kinematics; dynamics; trajectory planning; actuators and sensors; adaptive control and learning compliance; vision and pattern recognition; and expert systems.

ECE 471C Wireless Communications Laboratory 4 Hours
Examine the fundamentals of wireless communication from a digital signal processing perspective; linear modulation, demodulation, and orthogonal frequency division multiplexing; synchronization, channel estimation, and equalization; communication in fading channels; and wireless standards.

ECE 371D Introduction to Neural Networks 3 Hours
Explore characteristics of artificial neural networks, feedforward networks, and recurrent networks; learning algorithms; self-organization; biological links; and data mining and other applications.

ECE 371M Communication Systems 3 Hours
Explore analog and digital modulation; noise in communication systems; signal-to-noise ratio; coding; optimal receiver design; phase-locked loops; and performance analysis.

ECE 371P Introduction to Computer Vision 3 Hours
Examine image representation (by both human brain and digital); image filtering and edge detection; keypoint detection and matching; camera model and geometric calibration; stereo vision and essential/fundamental matrices; triangulation and epipolar geometry; depth estimation; video and optical flow; classical machine learning concepts; image classification; object detection and segmentation; deep learning for computer vision (basics).

ECE 371Q Digital Image Processing 3 Hours
Examine digital image acquisition, processing, and analysis; two dimensional Fourier analysis; 2D wavelets; image filtering; image denoising; image compression; machine learning for image processing and analysis; deep learning of images; picture quality prediction; image analysis; 3D stereoscopic ranging.

ECE 472L Network Engineering Laboratory 4 Hours
Explore local, metropolitan, and wide-area operations; telecommunication common carrier organizations and services; administrative and political considerations; premise distribution systems; name resolution, address assignment, and mail; datagrams, packets, frames, and cells; addressing and network-level interconnection; internetwork architecture; TCP/IP protocol suite (v. 4 and 6); Ethernet and IEEE 802.3 standards; IEEE 802.11 standards and wireless access points; repeaters, hubs, bridges, routers; local area network emulation; public switched network access through POTS and ISDN; intradomain and interdomain routing; routing protocols, including RIP, OSPF, and BGP; multicast; media testing; and local- and wide-area diagnostic tools.

ECE 372N Telecommunication Networks 3 Hours
Examine the operation of modern communication networks. Discuss the concept of layered network architecture to gain practical insights on the principal functions and services required for achieving reliable end-to-end communications. Explore networking application design and programming; service interfaces and peer-to-peer protocols; the reference model for TCP/IP; IEEE LAN (Local Area Network) architectures; network-layer and transport-layer issues; link layer with focus on contention-based access; wireless networks that cover WiFi; and basics of cellular networks.

ECE 372S Cryptography and Network Security 3 Hours
Explore distributed information system security, cryptographic tools, authentication, message security, and system management.

ECE 374K Biomedical Electronic Instrument Design 3 Hours
Explore the application of electrical engineering principles in the design of electronic instrumentation at the circuit-board level for the measurement of pressure, temperature, flow, and impedance. Examine the study of light intensity, bioelectric potentials, and stimulation devices such as pacemakers and defibrillators. Focus on design considerations specific to electro-medical environments, safety and efficacy, and public policy issues.

ECE 374L Applications of Biomedical Engineering 3 Hours
Examine areas of biomedical engineering, such as optical and thermal properties of laser interaction with tissue; measurement of perfusion in the microvascular system; diagnostic imaging; interaction of living systems with electromagnetic fields; robotic surgical tools; ophthalmic instrumentation; and noninvasive cardiovascular measurements.

ECE 374N Neural Engineering 3 Hours
Examine a variety of clinical conditions and their associated neurological basis, and then analyze the engineering solutions to cope with the neurological deficits, with an emphasis on electrical and computer engineering components. Study approaches to design motor neuroprosthetics and sensory neuroprosthetics that restore lost functions. Learn principles of deep brain stimulation, neuromodulation, and brain plasticity. Explore the concepts behind technological approaches for neurorehabilitation, in particular robotics and brain-computer interfaces.

ECE 679H Undergraduate Honors Thesis 6 Hours
Undertake research across two consecutive semesters under the supervision of an engineering faculty member. Investigate a research area, selected with a faculty member with approval by the director of the Honors Program. Deliver an oral presentation and write a thesis.

ECE 179K, 279K, 379K, 479K Topics in Electrical Engineering 1-4 Hours

ECE 380C Introduction to Optimization 3 Hours

ECE 380K Introduction to System Theory 3 Hours
Introduction to linear dynamical systems and differential equations, state space analysis and applications to feedback control, functional analytic methods, realization theory, stability theory, and elements of optimal control.

ECE 380L Topics in Computer Systems in Engineering 3 Hours

ECE 380L.11 Mining the Web 3 Hours
Analyze data and information available from the World Wide Web. Explore the exploitation of the hyperlink structure of the Web for developing better search engines. Examine content analysis; information retrieval, clustering, and hierarchical categorization of Web documents; web usage mining; and collaborative filtering and personalizing the Web.

ECE 380L.12 Real-Time Operating Systems Laboratory 3 Hours
Explore real-time operating systems; implementation of context switching, threads, multitasking, real-time scheduling, synchronization, communication, storage, file systems, memory management, process linking and loading, hardware interfacing, and networking; debugging and testing; operating system performance, including latency, jitter, deadlines, deadlocks, and starvation; real-time systems, including data acquisition, sensing, actuating, digital control, signal processing, and robotics.

ECE 380L.5 Engineering Programming Languages 3 Hours
Explore higher-level languages for engineering design and problem solving; object-oriented programming in C++ and Unix systems programming.

ECE 380L.7 Introduction to Pattern Recognition and Computer Vision 3 Hours

Explore pattern recognition, including Bayesian decision theory, maximum likelihood and estimation, nonparametric techniques, and linear discriminant functions. Examine computer vision, including geometric camera models and calibration, geometry of multiple views and stereopsis, structure from motion, and tracking.

ECE 380L.8 Computer Vision Systems 3 Hours

Discuss current research results and explore new directions in computer vision systems, including linear discriminant functions, nonmetric methods, unsupervised learning and clustering, model-based vision, segmentation using probabilistic methods, and content-based image and video analysis. Apply the techniques to real-world vision systems.

ECE 380L.9 Artificial Neural Systems 3 Hours

Examine feed-forward networks, distributed associative memory, recurrent networks, self-organization, parallel implementation, and applications.

ECE 380N Topics in System Theory 3 Hours

ECE 380N.1 Nonlinear Systems: Input-Output Properties 3 Hours

ECE 380N.10 Robotics II 3 Hours

ECE 380N.11 Optimization in Engineering Systems 3 Hours

Formulation and solution of continuous optimization problems in engineering design and operations.

ECE 380N.2 Nonlinear Systems: Geometric Theory 3 Hours

ECE 380N.3 Adaptive Control Systems 3 Hours

ECE 380N.4 Learning Systems and Cybernetic Machines 3 Hours

ECE 380N.5 Stochastic Control Theory 3 Hours

Examine dynamic programming in finite and infinite horizon, models with imperfect state information, ergodic control problems, and adaptive and risk-sensitive control.

ECE 380N.7 Design of Computer-Controlled Systems 3 Hours

ECE 380N.8 Algorithms for Parallel and Distributed Computation 3 Hours

ECE 380N.9 Fundamentals of Robotics and Mechatronics 3 Hours

Explore the theory of robotics and mechatronics, with emphasis on control, sensing, actuation, low- and high-level vision. Examine manipulator geometry, kinematics, dynamics, and planning of trajectories.

ECE 381C Verification and Validation 3 Hours

ECE 381J Probability and Stochastic Processes I 3 Hours

Examine probability spaces, random variables, expectation, conditional expectation, stochastic convergence, characteristic functions, and limit theorems. Explore Markov and Gaussian processes, stationary processes, spectral representation, ergodicity, renewal processes, martingales, and applications to estimation, prediction, and queueing theory.

ECE 381K Topics in Decision, Information, and Communications Engineering 3 Hours

ECE 381K.1 Detection Theory 3 Hours

ECE 381K.11 Wireless Communications 3 Hours

Introduction to fundamental aspects of wireless communication systems including channel modeling, diversity, multiple antenna transmission and reception, beamforming, adaptive modulation. Explore multiuser communication concepts including OFDMA and SC-FDMA, spread spectrum and CDMA, and broadcast and MAC channels. Examine system-level modeling including network information theory, stochastic geometry, and network interference models.

ECE 381K.13 Analysis and Design of Communication Networks 3 Hours

Examine stochastic and deterministic traffic and queueing models. Explore techniques for call admission, routing, flow control, network optimization, estimation, and decision making in uncertain environments.

ECE 381K.14 Multidimensional Digital Signal Processing 3 Hours

Explore multidimensional signals and systems, multidimensional discrete Fourier analysis, discrete cosine transform, two-dimensional filters, beamforming, seismic processing, tomography, multidimensional multirate systems, image halftoning, and video processing.

ECE 381K.15 Communication Networks: Technology, Architectures, and Protocols 3 Hours

Explore network services and techniques, layered architectures, circuit and packet-switching networks, internetworking, switch architectures, control mechanisms, and economic issues.

ECE 381K.16 Digital Video 3 Hours

Examine video sampling and transform; video (retinal and cortical) filters; motion detection and estimation; statistical models of videos; neuroscience of video perception; natural video statistics; modern video compression standards; video quality prediction; video denoising; active contour models; and video saliency.

ECE 381K.17 Wireless Communications Laboratory 3 Hours

Explore the fundamentals of wireless communication from a digital signal processing perspective; linear modulation, demodulation, and orthogonal frequency division multiplexing; synchronization, channel estimation, and equalization; communication in fading channels; principles of multiple-input, multiple-output (MIMO) communication; and wireless standards.

ECE 381K.18 Convex Optimization 3 Hours

The fundamentals of convex optimization with a focus on modeling, computation and scale: convex sets and functions, unconstrained optimization via first and second-order methods, duality, constrained optimization, SDPs, stochastic and sub-gradient descent methods, ADMMs, and applications.

ECE 381K.19 Wireless Network Modeling and Performance Evaluation 3 Hours

Explore modeling of large wireless networks, random graphs, stochastic geometry, point processes, space and time averages, connectivity, stability, capacity, and network design optimization, with applications for cellular network, mobile ad hoc networks, device to device networks, and vehicular networks.

ECE 381K.2 Digital Communications 3 Hours

Explore characterization of baseband and passband communication signals and channels, digital modulation, and pulse shaping; optimum receivers in additive white Gaussian noise including matched-filtering, ML, and MAP detection and their bit error probability for M-ary modulation; inter-symbol interference channels, FIR and IIR equalization, multicarrier modulation, OFDM and frequency domain equalization. Introduction to information theory, channel capacity, error control codes, and ML sequence detection (Viterbi decoding). Examine applications to stationary wireless and wireline channels.

ECE 381K.20 Machine Learning on Real World Networks 3 Hours

Explore networks in natural and socio-technological systems. Examine network structure and dynamics, machine learning on real networks, clustering; network models, small worlds, scale free networks, preferential attachment, community structure, network-on-chip optimization and control, epidemics and rumors, human mobility, network embedding, deep learning on graphs, graph neural networks, and other networks.

ECE 381K.21 Computational Magnetic Resonance Imaging 3 Hours
Introduction to Magnetic Resonance Imaging (MRI), particularly focusing on computational co-design of the signal acquisition and post-processing algorithms. Discuss principles of MRI, including basic system hardware, spin physics, signal formation, contrast mechanisms, pulse sequence design, image detection, and image reconstruction. Examine advanced image reconstruction including parallel imaging, compressed sensing, and machine learning; and exploration of concepts using real and synthetic data.

ECE 381K.3 Applied Machine Learning 3 Hours
Examine approaches to extracting valid and useful insights from data using statistically oriented approaches, with emphasis on predictive models learned from large-scale data sets. Code machine learning algorithms in Python and use various data visualization techniques.

ECE 381K.4 Statistical Machine Learning 3 Hours
Introduction to the theoretical underpinnings of machine learning and the derivations that transform those foundations into practical algorithms. Discuss empirical risk minimization and the probably approximately correct (PAC) learning framework; the bias-complexity tradeoff; the Vapnik-Chervonenkis dimension; Rademacher complexities; linear predictors; boosting; model selection and validation; convex learning problems; support vector machines and kernel methods; decision trees; clustering; dimensionality reduction; generative models; and variational Bayesian methods.

ECE 381K.5 Advanced Telecommunication Networks 3 Hours
Explore methods and research issues in the performance evaluation and management of high-speed and mobile communication networks.

ECE 381K.6 Estimation Theory 3 Hours

ECE 381K.7 Information Theory 3 Hours
Explore source and channel coding theorems, Kolmogorov complexity, network information theory, and connections with large deviations.

ECE 381K.8 Digital Signal Processing 3 Hours
Examine signals and systems; generalized functions; z-transforms; Fourier series and transforms; fast Fourier transform; sampling, quantization, and aliasing; digital filter design; discrete-time random processes; multirate processing; filter banks and subband decomposition; nonlinear digital filters.

ECE 381K.9 Advanced Signal Processing 3 Hours
Explore signal modeling; optimum filtering; spectral estimation; fast algorithms; and applications in array signal processing, speech coding, and digital communication.

ECE 381L Digital Time Series Analysis and Applications 3 Hours
Examine digital implementation of higher-order spectra and other techniques useful in analyzing, interpreting, and modeling random time series data from linear and nonlinear physical systems.

ECE 381M Probability and Stochastic Processes II 3 Hours
Examine random walk and Brownian motion; renewal and regenerative processes; Markov processes; ergodic theory; continuous parameter martingales; stochastic differential equations; diffusions; stochastic control; and multidimensional stochastic models.

ECE 381S Space-Time Communication 3 Hours
Explore multiple-input multiple-output (MIMO) wireless communication, including discrete-time signal models, equalization, and channel estimation; channel models; channel capacity; average probability of error in fading channels; channel coding; transmit and receive diversity; space-time codes; spatial multiplexing; precoding and limited feedback; space-time adaptation; multiuser communication; multiuser information theory; practical multiuser algorithms; and applications in recent standards.

ECE 381V Topics in Communications, Networks, and Systems 3 Hours

ECE 382C Topics in Software Engineering and Systems 3 Hours

ECE 382C.1 Engineering Design of Software and Software Systems 3 Hours
Explore the software development process; selection and application of software design methods; and evaluation of software designs.

ECE 382C.10 Unconventional Computation 3 Hours
Explore a variety of perspectives on computation, focusing on provable mathematical properties of the various models, and on how to use the models to achieve desired computational behavior. Discuss mechanical and electronic analog computation; linear threshold units (neural networks); cellular automata, Turing machines, and uncomputability; reversible computing and thermodynamics of computation; and quantum computing.

ECE 382C.11 Requirements Engineering 3 Hours

ECE 382C.12 Multicore Computing 3 Hours
Examine theoretical and practical aspects of designing multicore software systems; programming constructs for concurrent computation, openMP, sequential consistency, linearizability, lock-based synchronization, lock-free synchronization, wait-free synchronization, consensus number, software transactional memory, testing and debugging parallel programs, race detection, concurrent data structures such as stacks, queues, linked lists, hash tables and skip lists, formal models, temporal logic, reachability analysis, and parallel graph algorithms.

ECE 382C.13 Mobile Computing 3 Hours
Explore an overview of emerging research areas in mobile computing with a specific focus on the software engineering ramifications of mobile and pervasive computing technologies. Develop a solid foundation to support future discourse and research in the areas of mobile and pervasive computing, and skills to critically read research papers, assimilate information, find additional resources, and draw connections.

ECE 382C.14 Software Evolution Principles 3 Hours
Review program analysis techniques for evolving software; incremental testing, debugging, and verification; static and dynamic dependency analysis; program transformations; and software visualization.

ECE 382C.15 Middleware Architecture and Design 3 Hours
Introduction to the design of distributed computing middleware, with a focus on architectural principles. Explore an overview of required functions of emerging middleware and how middleware is designed to support these functions. Examine particular domains such as middleware for mobile computing, middleware for embedded systems, and middleware for sensor networks.

ECE 382C.16 Software Testing 3 Hours
Examine basic concepts and techniques for testing software and finding bugs. Explore the testing process; unit, integration and system testing; manual and automatic techniques for generation of test inputs and validation of test outputs; and coverage criteria. Focus on functional testing.

ECE 382C.17 Algorithmic Foundations for Software Systems 3 Hours
Examine complex data structures and algorithms, graph algorithms, performance analysis, correctness analysis, engineering effective techniques, and domain-specific methods, such as systematic or heuristic search.

ECE 382C.18 Computer Graphics 3 Hours
Examine computer graphics, including in-depth treatments of techniques for realistic image synthesis, advanced geometric modeling methods, animation and dynamic simulation, scientific visualization, and high-performance graphics architectures.

ECE 382C.2 Creation and Maintenance of Distributed Software Systems 3 Hours

Examine the creation of large distributed software applications, with emphasis on specification, failure models, correctness, and security.

ECE 382C.3 Verification and Validation of Software 3 Hours

Evaluate software for correctness, efficiency, performance, and reliability.

ECE 382C.4 Software and Hardware Engineering Project Management 3 Hours

Examine the requirements for a project management plan; role of the manager of the software development life cycle; economic and customer-driven factors.

ECE 382C.5 Large Software, Hardware, and Communications Systems Engineering 3 Hours

Explore the techniques used to specify and design systems of software, hardware, and communications components. Create a requirements document and system specification.

ECE 382C.6 Software for Highly-Available Distributed Applications 3 Hours

ECE 382C.7 Software Architectures 3 Hours

Explore the definitions, motivations, and utility of software system architectures from a technical and business perspective; derivation, specification, and analysis of architectural views in support of different phases in the system engineering lifecycle; methods to judge architectural quality; and communication of architectural views to a wide range of system stakeholders.

ECE 382C.8 Theory Blockchains and Smart Contracts 3 Hours

Explore blockchains and smart contracts, including but not limited to distributed consensus; layer 1 protocol architecture; associated cryptosystems; decentralized peer to peer networks; properties of blockchains; design of blockchain protocols and associated cryptosystems; security and privacy; scalability; liveness of such networks; proof of work; stake and other consensus mechanisms; and incentive design for participation in decentralized systems. Examine decentralized finance and decentralized applications.

ECE 382C.9 Embedded Software Systems 3 Hours

Examine dataflow models, uniprocessor and multiprocessor scheduling, hardware/software codesign, hierarchical finite state machines, synchronous languages, reactive systems, synchronous reactive languages, and heterogeneous systems.

ECE 382L Topics in Theory of Digital Systems 3 Hours

ECE 382L.1 Switching Theory 3 Hours

Explore general theory and realization algorithms for combinational, sequential, and array logic.

ECE 382L.2 Graph Theory and Applications 3 Hours

Examine elementary graph theory concepts; graph theory algorithms and applications in multicomputer architecture, switching and coding theory, data structures, computer networks, programming, algorithm analysis, diagnosis and fault tolerance.

ECE 382M Topics in Integrated Circuits and Systems 3 Hours

ECE 382M.1 VLSI Testing 3 Hours

Examine hardware and software reliability analysis of digital systems; testing, design for testability, self-diagnosis, fault-tolerant logic design, error-detecting and error-correcting codes.

ECE 382M.10 Synthesis of Digital Systems 3 Hours

Explore automatic generation of gate-level implementations from hardware description language (HDL) specifications; optimization of two-level, multilevel, and sequential circuits for area, speed, and testability.

ECE 382M.11 Verification of Digital Systems 3 Hours

Examine automatic verification of digital systems; formal models and specifications, equivalence checking, design verification, temporal logic, binary decision diagrams (BDDs), logical foundations, automata theory, recent developments.

ECE 382M.12 Semiconductor Memory Design 3 Hours

Examine semiconductor memory design in depth. Explore volatile memory circuit designs with static random access memory (SRAM), dynamic RAMs (DRAM), multi-ported RAMs, and content addressable memories (CAMs). Explore non-volatile semiconductor memory designs such as read-only-memories, resistive RAM, magnetic RAM, FLASH, and 3D memories. Discuss in-memory and near-memory computing circuit techniques for machine learning and artificial intelligence applications.

ECE 382M.13 Analysis and Design of Digital Integrated Circuits 3 Hours

Examine device and circuit-level aspects of metal oxide semiconductors (MOS) digital integrated circuit design.

ECE 382M.14 Analog Integrated Circuit Design 3 Hours

Explore the analysis and design of analog integrated circuits; transistor models and integrated circuit technologies; layout techniques; noise; mismatches; current mirrors; differential amplifiers; frequency response and compensation; feedback and stability; nonlinear circuits; voltage references; and operational amplifiers using state-of-the-art computer-aided design (CAD) tools for design, simulation, and layout.

ECE 382M.16 Application-Specific Processing 3 Hours

Examine techniques for the design and analysis of application-specific processors, including special purpose systems, embedded processors, and systems-on-chip.

ECE 382M.17 High-Level Synthesis of Digital Systems 3 Hours

Examine the synthesis from high-level languages (C) to RTL; allocation, scheduling and binding algorithms, and optimizations under area and performance objectives and constraints.

ECE 382M.19 Mixed-Signal System Design and Modeling 3 Hours

Explore architecture development for mixed-signal integrated circuits. Model analog and digital filters, data converters, and digital data receivers.

ECE 382M.2 Dependable Computing 3 Hours

Examine design techniques for reliable, fault-tolerant, fail-safe and fail-soft systems; fault diagnosis and fault avoidance methods at program and system levels; experimental and commercial fault-tolerant computer systems.

ECE 382M.20 System-on-Chip Design 3 Hours

Examine the methodologies and tools for System-on-Chip (SoC) design, hardware/software co-design and co-verification; partitioning; real-time scheduling; hardware acceleration; high-level C-to-RTL synthesis; allocation, scheduling and binding algorithms for hardware synthesis; SoC integration, communication architectures and hardware/software interfacing; virtual prototyping and hardware/software co-simulation; FPGA prototyping of hardware/software systems.

ECE 382M.22 VLSI Physical Design Automation 3 Hours

Examine algorithms and methodologies in circuit partitioning, floorplanning, global placement, detailed placement, global routing, detailed routing, clock tree routing, and power and ground routing. Explore new trends in physical design.

ECE 382M.23 Low-Power and Robustness Design 3 Hours

Examine nanometer transistors and models; design-time and runtime techniques for dynamic and standby power minimization; power minimization at circuit and architecture levels; power minimization for logic, memory, and interconnect; sources of variability; statistical data collection and analysis of variance; statistical circuit simulation and timing analysis; manufacturability and resolution enhancement techniques.

ECE 382M.24 Analog-Digital Data Conversion Circuits 3 Hours

Explore the analysis and design of analog-digital data conversion circuits including both architectural-level and transistor-level design considerations; design trade-offs among power, noise, linearity, and speed; sample-and-hold circuits and voltage comparators; noise analysis for mixed-signal circuits; flash, pipelined, successive approximation, and delta-sigma oversampling analog-to-digital-converters (ADCs); resistor-string, R-2R, current-steering, and delta-sigma oversampling digital-to-analog-converters (DACs); and the use of state-of-the-art computer-aided design (CAD) tools for analysis, design, and validation.

ECE 382M.25 Radio Frequency Integrated Circuit Design 3 Hours

Examine noise and distortion in devices and circuits; amplifier design techniques for low noise, variable gain, high output power, and high dynamic range; analysis and design of integrated mixers and other frequency converters; voltage and current mode mixers; rectifiers; integrated oscillators for generating fixed and variable frequencies; relevant performance metrics and trade-offs; noise in linear and non-linear time varying circuits; circuit techniques for linearity enhancement; design optimization in bipolar and complementary metal-oxide-semiconductor (CMOS) technologies. Explore transceiver architectures.

ECE 382M.26 VLSI CAD and Optimization 3 Hours

Explore interconnect and gate modeling; timing analysis; interconnect topology optimization; gate sizing; buffer insertion and sizing; wire sizing and planning; crosstalk analysis and mitigation; clock network synthesis; interconnect planning; modern placement techniques; congestion mitigation; low power optimization; design for manufacturability and reliability; design and computer-aided design (CAD) for emerging technologies.

ECE 382M.7 VLSI I 3 Hours

Examine very-large scale integration (VLSI) circuit design. Explore complementary metal oxide semiconductor (CMOS) technology; static and dynamic CMOS combinational and sequential circuits; design of datapath elements; performance, power consumption, and testing. Use computer-aided design (CAD) tools for layout, timing analysis, synthesis, physical design, and verification.

ECE 382M.8 VLSI II 3 Hours

Examine microelectronic systems architecture; VLSI circuit testing methods; integration of heterogeneous computer-aided design tools; wafer scale integration; advanced high-speed circuit design and integration.

ECE 382M.9 Simulation Methods in CAD and VLSI 3 Hours

Examine techniques and algorithms for simulating large-scale digital and analog circuits.

ECE 382N Topics in Architecture, Computer Systems, and Embedded Systems 3 Hours

ECE 382N.1 Computer Architecture 3 Hours

Examine characteristics of instruction set architecture and microarchitecture; physical and virtual memory; caches and cache design; interrupts and exceptions; integer and floating-point arithmetic; I/O processing; buses; pipelining, out-of-order execution, branch prediction, and other performance enhancements; design trade-offs; and case studies of commercial microprocessors. Participate in an individual laboratory.

ECE 382N.10 Parallel Computer Architecture 3 Hours

Study parallel computing, including models, algorithms, languages, compilers, interconnection networks, and architectures.

ECE 382N.11 Distributed Systems 3 Hours

Examine tracking dependency, mutex algorithms, snapshot algorithms, leader election, spanning tree, distributed algorithms, Map-Reduce, slicer, termination detection, message order, synchronizers, self-stabilization, knowledge, consensus, Byzantine agreement, fault-tolerance.

ECE 382N.14 High-Speed Computer Arithmetic I 3 Hours

Explore the design of computer arithmetic units: fast adders, fast multipliers, dividers, and floating-point arithmetic units.

ECE 382N.15 High-Speed Computer Arithmetic II 3 Hours

Explore advanced computer arithmetic, including error correcting coding, residue number systems, CORDIC arithmetic, and VLSI implementation.

ECE 382N.16 Distributed Information System Security 3 Hours

ECE 382N.17 Superscalar Microprocessor Architectures 3 Hours

Examine superscalar processor architectures; instruction level parallelism; machine level parallelism; superscalar organization; instruction windows; reservation station; register data flow; register renaming; reorder buffers; memory disambiguation; branch prediction; value prediction; instruction reuse techniques; comparison with very long instruction word (VLIW), single instruction-multiple data (SIMD), and multiple instruction-multiple data (MIMD) approaches; memory systems for superscalar processors; design for performance and power efficiency; performance evaluation of superscalar processors; and case studies.

ECE 382N.18 Distributed Systems II 3 Hours

ECE 382N.19 Microarchitecture 3 Hours

Explore concepts in architecture and microarchitecture. Examine critical path, bread-and-butter design, partitioning, timing, and pipelining; data path, state machine, microsequencer, microinstruction, microcode, microprogramming, and CAD tools; pipelining, branch prediction, and out-of-order execution; trace cache, block-structured ISA, simultaneous multithreading, and clustering; single instruction-multiple data (SIMD), very long instruction word (VLIW), decoupled access/execute (DAE), high performance switch (HPS), and data flow. survey the impact of compiler technology, reduced instruction set computing (RISC), and predicated execution; multiprocessor issues, cache coherency, memory consistency, and graphics processing units (GPUs); IEEE Floating Point, and example state-of-the-art microarchitectures.

ECE 382N.20 Computer Architecture: Parallelism and Locality 3 Hours

Examine hardware and software parallelism and locality mechanisms, and their impact on processor performance, bandwidth, and power requirements; architectures and microarchitectures of throughput-oriented processors that rely on parallelism, locality, and hierarchical control; parallel memory systems; and streaming and bulk execution and programming models. Explore programming and measuring performance on massively parallel processors.

ECE 382N.21 Computer Performance Evaluation and Benchmarking 3 Hours

Examine performance analysis of microprocessors and computer architectures; impact of performance analysis on microprocessor design; techniques for analysis of architectural trade-offs; performance and power modeling; performance metrics; benchmarks, measurement tools, and techniques; simulation, challenges in full-system simulation; instruction profiling; trace generation; sampling; simulation points; analytical modeling; calibration of microprocessor performance models; workload characterization; benchmarks for emerging programming paradigms; synthetic benchmarks; statistical methods to compare alternatives; linear regression; and design of experiments.

ECE 382N.22 Computer Architecture: User System Interplay 3 Hours
Explore fundamental principles in computer architecture focusing on the hardware and the compiler, as well as developing an understanding of their interplay with each other and with usage and programming models. Examine the development of several system families and follow common threads of identifying the intended users, system properties, and evaluation methodology. Review case studies including PCs and workstations with general-purpose processors, large parallel systems, graphics processors, and more experimental architectures such as stream processing and transactional memory.

ECE 382N.23 Embedded System Design and Modeling 3 Hours
Examine the methods and techniques for formal specification, modeling, and system-level design of embedded systems; models of computation (MoCs), concurrency and time including finite state machines (FSMs), process networks and dataflow; system-level design languages (SLDLs) and methodologies; system-level synthesis algorithms for partitioning, scheduling and design space exploration; system refinement and implementation models; virtual platform prototyping, system simulation and transaction-level modeling (TLM); hardware and software synthesis; system-level design tools and case studies.

ECE 382N.24 Code Generation and Optimization 3 Hours
Generate executable machine code understood by machines from program source code understood by programmers. Explore program optimization for performance, energy efficiency and reliability; code generation and optimization for different types of hardware; and runtime systems and just-in-time compilation.

ECE 382N.25 Runtime Systems 3 Hours
Examine fundamentals of runtime systems; design, implementation, and optimization of emulation engines; interpreters; binary translators; dynamic binary optimization; high-level language virtual machines; co-designed virtual machines; system-level virtual machines; and processor virtualization.

ECE 382N.26 Machine Learning Hardware-Algorithm Codesign 3 Hours
Explore co-design of machine learning (ML) algorithms and hardware; foundations of ML, compute-intensive ML architectures, high-performance matrix multiplication, spatial computing, roofline modeling, and scheduling and dataflows; ML-specific numerics, compression, quantization, and architectures for edge and mobile; codesign for scaling and system considerations; and circuit-level techniques for ultra-low-power ML, analog, and processing-in-memory techniques.

ECE 382N.3 Interconnection Networks 3 Hours
Explore topologies, routing algorithms, permutations, resource allocations, performance evaluation, fault tolerance, VLSI design, parallel and distributed algorithms, languages for specifying protocols, and distributed operating systems.

ECE 382N.4 Advanced Embedded Microcontroller Systems 3 Hours
Examine hardware and software design of advanced microcontroller systems; embedded applications, Linux drivers, handlers, and kernel modules, file systems, debugging; hardware acceleration, intelligent sensors and I/O subsystems, embedded field-programmable gate array (FPGAs), and networking-on-chip.

ECE 382V Topics in Computer Engineering 3 Hours

ECE 383L Electromagnetic Field Theory 3 Hours
Examine vector space, Green's function; equivalence theorem; vector potentials; plane, cylindrical, and spherical waves; and radiation and scattering.

ECE 383M Microwave Field Theory 3 Hours
Examine guided waves in cylindrical waveguides, microstrip lines, dielectric and optical waveguides; integrated circuits; and periodic structures.

ECE 383N Theory of Electromagnetic Fields: Electrodynamics 3 Hours
Explore intermediate electromagnetic field theory, with emphasis on the interaction of fields and material media, including anisotropic media.

ECE 383P Topics in Optical Processing and Laser Communications 3 Hours

ECE 383P.1 Fourier Optics 3 Hours
Examine Fourier transforming properties of lenses, frequency analysis of optical imaging systems, and spatial filtering. Explore optical information processing and holography.

ECE 383P.3 Techniques of Laser Communications 3 Hours
Examine optical propagation in crystalline media, harmonic generation, frequency conversion, and modulation systems.

ECE 383P.4 Fiber and Integrated Optics I 3 Hours
Examine waveguiding in slabs, cylinders, and fibers; optical fiber communications principles; mode coupling; guided-wave optical sources, modulators, and detectors.

ECE 383P.5 Fiber and Integrated Optics II 3 Hours
Examine principles and practices of guided-wave optical sensor technology. Explore nonlinear optical effects in fibers, including amplification and fiber lasers.

ECE 383P.6 Semiconductor Optoelectronic Devices 3 Hours
Examine semiconductor materials and nanomaterials growth. Review light-matter interaction in bulk and nanostructures, including both band-to-band and intersubband transitions. Discuss band structure in real-space and k-space. Explore photonic devices and their design: light-emitting diodes (LEDs), photodetectors, modulators, solar cells, and semiconductor lasers (diode and quantum cascade).

ECE 383P.8 Optical Communications 3 Hours
Explore the concepts behind research and development in optical communications and optical interconnects. Examine device physics and system applications. Discuss advanced technology solutions and innovative manufacturing processes to deliver optical passive and active micro- and nanodevices that enable the deployment of short-haul and metropolitan area all-optical networks for communications and for sensing networks.

ECE 383V Topics in Electromagnetics 3 Hours

ECE 384N Topics in Acoustics 3 Hours

ECE 384N.1 Acoustics I 3 Hours
Plane waves in fluids; transient and steady-state reflection and transmission; lumped elements; refraction; strings, membranes, and rooms; horns; ray acoustics; absorption and dispersion.

ECE 384N.2 Acoustics II 3 Hours
Spherical and cylindrical waves, radiation and scattering, multipole expansions, Green's functions, waveguides, sound beams, Fourier acoustics, Kirchhoff theory of diffraction, and arrays.

ECE 384N.3 Electromechanical Transducers 3 Hours
Modeling, analysis, and design of transducers for reception and transmission of acoustic and vibration signals; dynamics of coupled electrical, mechanical, and acoustical systems; and the effects of transducer characteristics on fidelity and efficiency of transduction.

ECE 384N.4 Nonlinear Acoustics 3 Hours
Waveform distortion and shock formation, harmonic generation and spectral interactions, effects of absorption and dispersion, parametric arrays, Rankine-Hugoniot relations, weak shock theory, numerical modeling, radiation pressure, and acoustic streaming.

ECE 384N.5 Underwater Acoustics 3 Hours
Acoustic properties of the ocean; acoustic propagation, reflection, reverberation, scattering and target strength; ocean noise; introduction to array and signal processing; basics of sonar design.

ECE 384N.6 Architectural Acoustics 3 Hours

Human perception of sound, principles of room acoustics, sound-absorptive materials, transmission between rooms, and acoustical design of enclosed spaces.

ECE 384N.7 Ultrasonics 3 Hours

Acoustic wave propagation in fluids, elastic solids, and tissue; transducers, arrays, and beamforming; nondestructive evaluation; and acoustical imaging.

ECE 384N.8 Wave Phenomena 3 Hours

Fourier acoustics and angular spectra; nearfield acoustical holography; Fraunhofer, Fresnel, and parabolic approximations; sound beams; Green's functions; Born approximation; propagation and scattering in moving, periodic, and random media.

ECE 384N.9 Acoustic Metamaterials 3 Hours

Examine wave propagation in heterogeneous media displaying nonclassical effective properties. Introduction to effective medium theories including fundamental limits on effective properties, transmission and scattering matrices, waves in periodic media, localized resonance, and transformation acoustics.

ECE 385J Topics in Biomedical Engineering 3 Hours

ECE 385J.1 Neural Engineering 3 Hours

Examine a variety of clinical conditions and their associated neurological basis, and then analyze the engineering solutions to cope with the neurological deficits, with an emphasis on electrical and computer engineering components. Study approaches to design motor neuroprosthetics and sensory neuroprosthetics that restore lost functions. Learn principles of deep brain stimulation, neuromodulation, and brain plasticity. Explore the concepts behind technological approaches for neurorehabilitation, in particular robotics and brain-computer interfaces.

ECE 385J.15 Biosignal Analysis 3 Hours

Theory and classification of biological signals such as EEG, EKG, and EMG. Data acquisition and analysis procedures for biological signals, including computer applications.

ECE 385J.16 Laser-Tissue Interaction: Optical 3 Hours

The optical behavior of random media such as tissue in interaction with laser irradiation. Approximate transport equation methods to predict the absorption and scattering parameters of laser light inside tissue. Port-wine stain treatment; cancer treatment by photochemotherapy; and cardiovascular applications.

ECE 385J.17 Biomedical Instrumentation II: Real-Time Computer-Based Systems 3 Hours

Design, testing, patient safety, electrical noise, biomedical measurement transducers, therapeutics, instrumentation electronics, microcomputer interfaces, and embedded systems. Participate in an individual laboratory.

ECE 385J.18 Imaging Signals and Systems 3 Hours

Physical principles and signal processing techniques used in thermographic, ultrasonic, and radiographic imaging, including image reconstruction from projections such as CT scanning, MRI, and millimeter wave determination of temperature profiles.

ECE 385J.23 Optical Spectroscopy 3 Hours

Measurement and interpretation of spectra: steady-state and time-resolved absorption, fluorescence, phosphorescence, and Raman spectroscopy in the ultraviolet, visible, and infrared portions of the spectrum.

ECE 385J.26 Therapeutic Heating 3 Hours

Engineering aspects of electromagnetic fields that have therapeutic applications: diathermy (short wave, microwave, and ultrasound), electrosurgery (thermal damage processes), stimulation of excitable tissue, and electrical safety.

ECE 385J.28 Noninvasive Optical Tomography 3 Hours

Basic principles of optical tomographic imaging of biological materials for diagnostic or therapeutic applications. Optical-based tomographic imaging techniques including photothermal, photoacoustic, and coherent methodologies.

ECE 385J.3 Bioelectric Phenomena 3 Hours

Examines the physiological bases of bioelectricity and the techniques required to record bioelectric phenomena both intracellularly and extracellularly; the representation of bioelectric activity by equivalent dipoles and the volume conductor fields produced.

ECE 385J.31 Biomedical Instrumentation I 3 Hours

Application of electrical engineering techniques to analysis and instrumentation in biological sciences: pressure, flow, temperature measurement; bioelectrical signals; pacemakers; ultrasonics; electrical safety; electrotherapeutics.

ECE 385J.32 Projects in Biomedical Engineering 3 Hours

An in-depth examination of selected topics, such as optical and thermal properties of laser interaction with tissue; measurement of perfusion in the microvascular system; diagnostic imaging; interaction of living systems with electromagnetic fields; robotic surgical tools; ophthalmic instrumentation; noninvasive cardiovascular measurements.

ECE 385J.33 Neurophysiology/Prosthesis Design 3 Hours

The structure and function of the human brain. Discussion of selected neurological diseases in conjunction with normal neurophysiology. Study of neuroprosthesis treatments and design philosophy, functional neural stimulation, and functional muscular stimulation.

ECE 385J.35 Brain-Computer Interaction 3 Hours

Examine the architecture of a brain-computer interface (BCI), the brain signals that can be recorded as input to a BCI, and the interaction paradigms where these signals can be decoded and exploited. Study the design principles of complex brain-controlled devices, with an emphasis on electroencephalogram (EEG) signals, the most common signal for BCI. Explore how to enhance EEG signal-to-noise ratio, and techniques to decode subjects' intents and cognitive states. Apply those techniques EEG signals acquired during closed-loop BCI experiments.

ECE 385J.9 Laser-Tissue Interaction: Thermal 3 Hours

The thermal response of random media in interaction with laser irradiation. Calculation of the rate of heat production caused by direct absorption of the laser light, thermal damage, and ablation.

ECE 386C Software Architecture 3 Hours

ECE 390C Statistical Methods in Engineering and Quality Assurance 3 Hours

Examine the interpretation of data from designed experiments and production processes. Explore subjects including probability distributions, confidence intervals, analysis of variance, hypothesis testing, factorial designs, and quality control data.

ECE 390V Topics in Manufacturing Systems Engineering 3 Hours

ECE 391C Technical Entrepreneurship 3 Hours

Examine the technology-based company: entrepreneurship, intrapreneurship, strategic planning, finance, marketing, sales, operations, research and development, manufacturing, and management. Form hypothetical companies in a team and simulate their ventures over an extended period.

ECE 392C Software Testing 3 Hours

ECE 392K Antenna Theory and Practice 3 Hours

Explore modern antenna systems for receiving and transmitting, including driven and parasitic arrays, horns, parabolic and other antennas.

ECE 392L Computational Electromagnetics 3 Hours

Explore fundamental computational modeling and analysis techniques for applications in antennas, microwave circuits, biomedical engineering, and geophysics. Focus on boundary-value problem formulation, numerical methods, computer implementation, and error quantification. Examine differential and integral equation-based methods for solving Maxwell's equations in frequency and time domains.

ECE 392N Principles of Radar 3 Hours

Explore the fundamentals of radar, with an emphasis on electromagnetics and signal processing. Examine radar range equation, antennas, propagation and target scattering, matched filter, ambiguity function, waveform design, pulse compression, microwave imaging, synthetic aperture radar, and inverse synthetic aperture radar (ISAR).

ECE 393C Topics in Plasma Dynamics 3 Hours

ECE 393C.1 Introduction to Plasma Dynamics 3 Hours

Examine plasma properties, including collective effects, Debye shielding, quasineutrality, the plasma frequency, and collisions. Explore single particle motions in electric and magnetic fields. Study particle drifts, adiabatic invariants, and cyclotron resonance.

ECE 394 Topics in Power System Engineering 3 Hours

ECE 394.14 Electrical Transients in Power Systems 3 Hours

Explore analysis and modeling of electrical transient phenomena in power systems, traveling wave, insulation coordination, and overvoltage protection.

ECE 394.15 Power System Operations and Control 3 Hours

ECE 394.16 Restructured Electricity Markets: Locational Marginal Pricing 3 Hours

Examine locational marginal pricing (LMP) model of electricity markets. Explore market dispatch formulated as an optimization problem, unit commitment issues, and pricing rules and incentives in markets; energy-price and transmission-price risk hedging and energy network models; and revenue adequacy of financial transmission rights, a mixed-integer programming approach to unit commitment, the representation of voltage constraints into market models, and the design of electricity markets to mitigate market power.

ECE 394.17 Restructured Electricity Markets: Market Power 3 Hours

Explore the definition and analysis of market power, especially as an issue in the design and functioning of electricity markets. Focus on transmission constraints and offer-based markets that involve locational marginal pricing.

ECE 394.18 Electric Machinery and Drive Systems 3 Hours

Explore electric drives and machines used in commercial and industrial applications. Examine magnetic circuits and magnetic materials; electromechanical energy conversion principles; rotating and linear machine concepts, including synchronous, induction, DC, and variable reluctance; and control strategies.

ECE 394.7 Power Electronic Devices and Systems 3 Hours

Explore power electronic components and circuits; high-voltage, direct current (HVDC) converters; electronic drives for machines; AC/DC converters.

ECE 394.9 Power Quality 3 Hours

Examine electrical transients, switching surges, lightning, and other phenomena that cause deviations in 60-hertz sinusoidal voltages and currents.

ECE 394J Topics in Energy Systems 3 Hours

ECE 394J.1 Power System Engineering I 3 Hours

Examine physical features, operational characteristics, and analytical models for major electric power systems and components.

ECE 394J.10 Distributed Generation Technologies 3 Hours

Examine distributed generation and microgrids elements; microsources; energy storage; power electronics interfaces; DC and AC architectures; economics, operation, stabilization, and control; reliability and availability aspects; interaction between microgrids and bulk power grids; and smart grids.

ECE 394J.11 Advanced Power Electronics 3 Hours

Explore resonant converters, switched-capacitor converters, the dual active bridge converter, high-frequency magnetics, high-frequency inverters and rectifiers, power factor correction, and other areas of current interest. Undertake projects with intensive design, prototyping, and/or simulation components.

ECE 394J.12 Modeling and Simulation of Wind Power Plants 3 Hours

Explore the analysis, modeling, and simulation of wind turbines and wind farms; fundamentals of wind turbines and technologies, reference-frame theory, dynamic models of induction and synchronous machines, fixed-speed direct-connect, wide-slip, doubly-fed, full-converter wind turbines, operation and control, and interconnection issues.

ECE 394J.2 Power System Engineering II 3 Hours

Explore advanced techniques for solving large power networks; load flow, symmetrical components, and short circuit analysis.

ECE 394J.9 Wind Energy Systems 3 Hours

Examine wind resource characteristics and assessments; wind turbine technologies (fixed and variable-speed turbines); wind power transmission; integration and interconnection issues; and reliability impacts.

ECE 394L Power Systems Apparatus and Laboratory 3 Hours

Examine the fundamentals of power systems emphasized through laboratory experiments. Explore complex power, three-phase circuits, per-unit system, transformers, synchronous machines, transmission line models, steady-state analysis, induction machines, capacitor banks, protective relaying, surge arrestors, and instrumentation.

ECE 396K Topics in Solid-State Device Theory 3 Hours

Explore the theory of electron, magnetic, and electro-optic devices.

ECE 396K.1 Metal Oxide Semiconductor Devices: Physics and Technology 3 Hours

ECE 396K.10 Ionic Conductors 3 Hours

ECE 396K.11 High-Temperature Superconductors 3 Hours

ECE 396K.12 Catalytic Electrodes 3 Hours

ECE 396K.13 Magnetic Materials 3 Hours

ECE 396K.14 Optical Interconnects 3 Hours

ECE 396K.15 Optoelectronics Integrated Circuits 3 Hours

ECE 396K.16 Semiconductor Lasers 3 Hours

Examine the principles of compound semiconductor lasers and LEDs; bulk and quantum-well laser structures; radiative and nonradiative recombination processes; optical, electrical, and thermal properties of lasers; dynamic rate equations and modulation characteristics; lasing spectra, chirp, modal noise and linewidth; and edge-emitting and surface-emitting lasers.

ECE 396K.17 Localized-Electron Phenomena 3 Hours

Analysis of the variation in physical properties versus chemical composition of several groups of isostructural transition-metal compounds.

ECE 396K.19 Plasma Processing of Semiconductors I 3 Hours

Explore plasma analysis using Boltzmann and fluid equations; plasma properties, including Debye length, quasineutrality, and sheaths; basic collisional properties, including Coulomb and polarization scattering; analysis of capacitive and wave-heated plasma processing reactors.

ECE 396K.2 Semiconductor Physics 3 Hours

Introduction to the fundamental physics of charge carrier states in semiconductors, charge carrier interactions among themselves and with the environment, and charge transport in semiconductors and their heterostructures.

ECE 396K.20 Plasma Processing of Semiconductors II 3 Hours

Explore plasma chemistry and equilibrium; analysis of molecular collisions; chemical kinetics and surface processes; plasma discharge particle and energy balance; analysis of inductive and DC plasma processing reactors; plasma etching, deposition, and implantation.

ECE 396K.21 Nanoscale Device Physics and Technologies 3 Hours

Examine physical principles and operational characteristics of semiconductor devices. Explore the physics of metal-oxide-semiconductor field-effect transistors (MOSFET) and bipolar junction transistors (BJT). Discuss short-channel effects, ultra-thin oxide, and high-K gate dielectrics; semiconductor interface characterization; hot-electron effects; lightly-doped drain devices (LDD); subthreshold characteristics; complementary-symmetry metal-oxide-semiconductor (CMOS) latchup; gate-induced leakage current of MOSFETs; poly-depletion and quantum mechanical effects; silicon on insulator (SOI) devices; strained-Si; advanced 3-D devices and bandgap narrowing effect; Webster effect; Kirk effect; punchthrough and avalanche breakdown; base transit time for bipolar transistors; and scaling issues of both BJT and MOSFETs.

ECE 396K.22 Semiconductor Microlithography 3 Hours

ECE 396K.23 Semiconductor Heterostructures 3 Hours

ECE 396K.24 Microwave Devices 3 Hours

ECE 396K.25 Organic and Polymer Semiconductor Devices 3 Hours

ECE 396K.26 Microelectromechanical Systems 3 Hours

ECE 396K.27 Charge Transport in Organic Semiconductors 3 Hours

ECE 396K.28 Magnetic Materials and Devices 3 Hours

Explore the fundamentals and applications of magnetic materials, in particular to nano-devices. Examine the origin of magnetism in oxides and metals, magnetic switching mechanisms, and how spin structures arise such as domain walls and topologically-protected spin states. Discuss applications to future computing nano-devices.

ECE 396K.29 Thin Film Transistors 3 Hours

Explore device physics of thin-film and 2D transistors, charge transport phenomena, and materials aspects. Discuss organic polymer and amorphous inorganic semiconductors (oxides and silicon). Study organic polymer and amorphous inorganic semiconductors (oxides and silicon), and field effect transistors with 2D semiconductors such as transition metal dichalcogenides (TMDs). Review change of properties with layer thickness, device physics and transport, contacts, and performance characteristics and discuss unusual properties of thin film transistors (TFTs) such as light emission and ambipolar charge transport, lateral junctions, and ionic gating.

ECE 396K.30 Solar Energy Conversion Devices 3 Hours

Study radiation from the Sun and the solar energy flux on Earth, and discuss the principles of semiconductors and semiconductor device physics relevant to diodes under various bias conditions. Examine the physics of pn junction under solar illumination and with various recombination mechanisms. Review the most important materials families of solar cells including single crystal silicon; polysilicon; amorphous silicon; solar cells based on CdTe and copper indium diselenide and related compounds; and III-V compound semiconductor heterojunction solar cells including tandem cells and space-grade solar cells. Discuss new materials technologies including organic and perovskite-based solar cells.

ECE 396K.4 Synthesis, Growth, and Analysis of Electronic Materials 3 Hours

ECE 396K.5 Superconducting Electronic Devices 3 Hours

ECE 396K.6 Magnetic Phenomena in Materials 3 Hours

ECE 396K.7 Metal Oxide Semiconductor Integrated Circuit Process Integration 3 Hours

ECE 396K.8 Ultra-Large-Scale Integration Techniques 3 Hours

Examine integrated circuit processing; crystal growth and wafer preparation; epitaxial growth; oxidation, diffusion, and ion implantation; thin-film deposition techniques; and lithography and etching. Participate in an individual laboratory.

ECE 396K.9 Localized versus Itinerant Electrons in Solids 3 Hours

Description of electrons, from free atoms to crystals; band theory contrasted with crystal-field theory; evolution of electronic properties on passing from magnetic insulators to normal metals, from ionic to covalent solids, from single-valent compounds to mixed-valent systems; electron-lattice interactions and phase transitions; many examples.

ECE 396M Topics in Quantum Electronics 3 Hours

Examine quantum mechanical principles as applied to electron devices, lasers, and electro-optics; material properties and interaction of radiation and material.

ECE 396M.1 Introductory Quantum Electronics 3 Hours

Examine basic quantum mechanics and applications to solid-state phenomena and lasers.

ECE 396M.2 Quantum Information Hardware 3 Hours

Explore various hardware platforms used for quantum information processing from an applied physics perspective. Examine the physical requirements for a hardware platform to process quantum information. Review characteristics of current hardware platforms such as superconducting quantum circuits, atomic systems, solid-state spins and optical photons.

ECE 396N Topics in Nanotechnology 3 Hours

ECE 396N.1 Semiconductor Nanostructures 3 Hours

Examine the theoretical framework for the understanding of electronic properties and electron transport in quantum confined devices; two-dimensional electron systems in semiconductor heterostructures; quantum wires; quantum dots; spintronic devices; and growth and fabrication techniques.

ECE 396N.2 Carbon and 2D Devices 3 Hours

Introduction to the material properties and device physics of carbon nanotubes, graphene and related 2D materials; science and technology of carbon nanomaterials and their electronic, optical, and sensor properties; and a basic review of quantum mechanics and elementary theory of solids. Examine carbon synthesis, sensor devices, energy devices, interconnects, transistors, and circuit applications of carbon nanomaterials. Explore 2D materials beyond graphene including transitional metal dichalcogenides.

ECE 396V Topics in Solid-State Electronics 3 Hours

ECE 396V.5 Introduction to Solid-State Properties of Materials 3 Hours

Introduction to the electronic, magnetic, and optical properties of materials. Solid-state properties of metals, semiconductors, and ceramics; fundamental concepts needed for the description of these properties, using an introductory-level description of the electronic structure of solids.

ECE 396V.6 Advanced Semiconductor Lasers 3 Hours

Examine dynamic properties of semiconductor lasers; intensity, phase, and frequency noise; dynamic lasing spectra, chirp, and mode partition noise; injection locking and optical feedback; short pulse generation by mode-locking and gain switching; single-mode distributed feedback, distributed Bragg reflector (DBR), and coupled-cavity lasers; wavelength-tunable single-mode lasers; externally modulated lasers; coherent high-power laser arrays; quantum-dot lasers and amplifiers; vertical-cavity surface-emitting lasers; and integrated wavelength-division multiplexing (WDM) laser arrays and photonic integrated circuits.

ECE 396V.7 Optoelectronics for Optical Networking 3 Hours

Examine advanced optical communication systems and optoelectronics technologies, including dense and coarse wavelength division multiplexing, soliton transmission, coherent detection, subcarrier multiplexing, nonregenerative erbium-doped fiber amplifier (EDFA) networks, and Raman amplification. Explore photonic switching system architectures and optical switching technologies, including both passive and active components.

ECE 197C, 297C, 397C, 697C, 997C Research Problems 1,2,3,6,9 Hours

Select and research a problem with approval of the department.

ECE 197G, 297G, 397G, 697G, 997G Research Problems 1,2,3,6,9 Hours

Problem selected by the student with approval of the department.

ECE 397K Advanced Topics in Electrical Engineering 3 Hours

ECE 197M, 297M, 397M Graduate Research Internship 1-3 Hours

Engage in research associated with enrollment in the Graduate Research Internship Program (GRIP).

ECE 397N Conference Course 3 Hours

ECE 197S, 297S, 397S Graduate Seminar in Electrical Engineering 1-3 Hours

ECE 698 Thesis 6 Hours

ECE 398R Master's Report 3 Hours

Prepare a report to fulfill the requirement for the Master's degree under the report option.

ECE 398T Supervised Teaching in Electrical Engineering 3 Hours

Teach under close supervision for one semester. Attend group meetings or individual consultations, and submit reports as required.

ECE 399W, 499W, 599W, 699W, 799W, 899W, 999W Dissertation 3-9 Hours