Electrical and Computer Engineering (ECE)

ECE 109 Introduction to Computer Systems (3 credit hours)
Introduction to key concepts in computer systems. Number representations, switching circuits, logic design, microprocessor design, assembly language programming, input/output, interrupts and traps.

Typically offered in Fall, Spring, and Summer

ECE 200 Introduction to Signals, Circuits and Systems (4 credit hours)
Ohm's law and Kirchoff's laws; circuits with resistors, photocells, diodes and LEDs; rectifier circuits; first order RC circuits; periodic signals in time and frequency domains, instantaneous, real and apparent power; DC and RMS value; magnitude andpower spectra, dB, dBW, operational amplifier circuits, analog signal processing systems including amplification, clipping, filtering, addition, multiplication, AM modulation sampling and reconstruction. Weekly hardware laboratory utilizing multimeter, function generator, oscilloscope and spectrum analyzer and custom hardware for experiments on various circuits and systems.

Prerequisite: Cum GPA 2.5 or above (or NTR) , C or better in MA 241 and PY 205
Typically offered in Fall, Spring, and Summer

ECE 209 Computer Systems Programming (3 credit hours)
Computer systems programming using the C language. Translation of C into assembly language. Introduction to fundamental data structures: array, list, tree, hash table.

Prerequisite: Grade of C- or better in ECE 109
Typically offered in Fall, Spring, and Summer

ECE 211 Electric Circuits (4 credit hours)
Introduction to theory, analysis and design of electric circuits. Voltage, current, power, energy, resistance, capacitance, inductance. Kirchhoff's laws node analysis, mesh analysis, Thevenin's theorem, Norton's theorem, steady state and transient analysis, AC, DC, phasors, operational amplifiers, transfer functions.

Prerequisite: C- or better in ECE 200 and Corequisite: ECE 220
Typically offered in Fall, Spring, and Summer

ECE 212 Fundamentals of Logic Design (3 credit hours)
Introduction to digital logic design. Boolean algebra, switching functions, Karnaugh maps, modular combinational circuit design, latches, flip-flops, finite state machines, synchronous sequential circuit design, datapaths, memory technologies, caches, and memory hierarchies. Use of several CAD tools for simulation, logic minimization, synthesis, state assignment, and technology mapping.

Prerequisite: C- or better in ECE 109
Typically offered in Fall, Spring, and Summer

ECE 220 Analytical Foundations of Electrical and Computer Engineering (3 credit hours)
This course is designed to acquaint you with the basic mathematical tools used in electrical and computer engineering. The concepts covered in this course will be used in higher level courses and, more importantly, throughout your career as an engineer. Major topics of the course include complex numbers, real and complex functions, signal representation, elementary matrix algebra, solutions to linear systems of equations, linear differential equations, laplace transforms used for solving linear differential equations, fourier series and transforms and their uses in solving ECE problems. EE and CPE Majors Only.

Prerequisite: C- or better in ECE 200
Typically offered in Fall, Spring, and Summer

ECE 298 Special Projects in ECE (1-4 credit hours)
Faculty-supervised special projects in electrical and/or computer engineering. Projects involve small groups of students, working collaboratively or independently, focused on a single theme, such as the design of a component or system. Requires a "Course Agreement for Students Enrolled in Non-Standard Courses," completed by the student and faculty member prior to registration by the department.

R: EE or CPE majors
Typically offered in Fall, Spring, and Summer

ECE 301 Linear Systems (3 credit hours)
Representation and analysis of linear systems using differential equations: impulse response and convolution, Fourier series, and Fourier and Laplace transformations for discrete time and continuous time signals. Emphasis on interpreting system descriptions in terms of transient and steady-state response. Digital signal processing.

Prerequisite: C- or better in ECE 211 and ECE 220.
Typically offered in Fall, Spring, and Summer

ECE 302 Microelectronics (4 credit hours)
Introduction to the physics of semiconductors, PN Junctions, BJT and MOS field Effect Transistors: Physics of operation, IV characteristics, load line, quiescent point of operation, PSPICE analysis; diode circuit analysis; voltage regulation; Single Stage Transistor Amplifiers: Common Emitter and Common Source configurations, biasing, inverting and non-inverting amplifiers; follower circuits; calculation of small signal voltage gain, current gain, coupling and bypass capacitors; Multistage ac-coupled amplifiers; small signal modeling; input resistance and output resistance; logic inverters.

Prerequisite: A grade of C- or better in ECE 211
Typically offered in Fall, Spring, and Summer

ECE 303 Electromagnetic Fields (3 credit hours)
This course prepared the students to formulate and solve electromagnetic problems relevant to all fields of electrical and computer engineering and that will find application in subsequent courses in RF circuits, photonics, microwaves, wireless networks, computers, bioengineering, and nanoelectronics. Primary topics include static electric and magnetic fields, Maxwell's equations and force laws, wave propagation, reflection and refraction of plane waves, transient and steady-state behavior of waves on transmission lines. Restriction: EE and CPE Majors Only.

Prerequisite: A grade of C- of better in ECE 211 and ECE 220
Typically offered in Fall, Spring, and Summer

ECE 304 Fundamentals of Semiconductor Devices (3 credit hours)
This course will introduce the fundamentals of semiconductor devices, which are the basic building blocks of all modern electronics. The course covers semiconductor physics and the operational principles of devices. Semiconductor physics topics include quantum mechanical concepts, crystallography, semiconductor bands, intrinsic/extrinsic properties, holes, effective mass, Fermi statistics, electron/hole concentrations, drift and diffusion currents, mobility, generation/recombination, lifetimes, diffusion lengths, and quasi-Fermi levels. Devices that are covered include p-n junctions (diodes), bipolar junction transistors (BJTs), metal-oxide-semiconductor field-effect transistors (MOSFETs), light-emitting diodes (LEDs), photodiodes, sensors, laser diodes, power diodes, power MOSFETs, and integrated gate bipolar transistors (IGBTs).

Prerequisite: ECE 211; credit not allowed for both ECE 304 and ECE 404
Typically offered in Fall and Spring

ECE 305 Principles of Electromechanical Energy Conversion (3 credit hours)
Three-phase circuits and power flow, analysis of magnetic circuits, performance of single-phase and three-phase transformers, principles of electromechanical energy conversion, steady-state characteristics and performance of alternating current and direct current machinery.

Prerequisite: C- or better in ECE 211 or ECE 331
Typically offered in Fall, Spring, and Summer

ECE 306 Introduction to Embedded Systems (3 credit hours)
Introduction to designing microcontroller-based embedded computer systems using assembly and C programs to control input/output peripherals. Use of embedded operating system.

Prerequisite: C- or better in ECE 209 and ECE 212
Typically offered in Fall and Spring

ECE 308 Elements of Control Systems (3 credit hours)
Analog system dynamics, open and closed loop control, block diagrams and signal flow graphs, input-output relationships, stability analyses using Routh-Hurwitz, root-locus and Nyquist, time and frequency domain analysis and design of analog control systems. Use of computer-aided analysis and design tools. Class project. EE, CPE, BME majors only.

Prerequisite: (ECE 220 and ECE 211) or BME 311; Co-requisite: ECE 301
Typically offered in Fall and Spring

ECE 309 Data Structures and Object-Oriented Programming for Electrical and Computer Engineers (3 credit hours)
Advanced programming topics focusing on data structures and object-oriented programming. Common data structures, including linked lists, hash tables, trees, balanced trees, heaps, graphs, and B-trees, are described, analyzed, and implemented. Object-oriented programming topics, classes, inheritance, polymorphism, abstract types, and generic types are described and applied to program design.

Prerequisite: C- or better in ECE 209
Typically offered in Fall and Spring

ECE 310 Design of Complex Digital Systems (3 credit hours)
Design principles for complex digital systems. Decomposition of functional and interface specifications into block-diagrams and simulation with hardware description languages. Synthesis of gate-level descriptions from register-transfer level descriptions. Design and test of increasingly complex systems.

Prerequisite: A grade of C- or better in ECE 212
Typically offered in Fall and Spring

ECE 331 Principles of Electrical Engineering (3 credit hours)
Concepts, units and methods of analysis in electrical engineering. Analysis of d-c and a-c circuits, characteristics of linear and non-linear electrical devices; principles of operational amplifiers; transformers; motors; and filters.

Prerequisite: PY 208 and a C or better in MA 241
Typically offered in Fall, Spring, and Summer

ECE 380 Engineering Profession for Electrical Engineers (1 credit hours)
Introduction to engineering as a profession including issues surrounding electrical engineering. Topics include professional and ethical responsibilities, risks and liabilities, intellectual property, and privacy. Economic issues including entrepreneurship and globalization.

Pre-requisites: C- or better in ECE 211 and ECE 212 and ECE 220
Typically offered in Fall and Spring

ECE 381 Engineering Profession for Computer Engineers (1 credit hours)
Introduction to engineering as a profession including issues surrounding computer engineering. Topics include professional and ethical responsibilities, risks and liabilities, intellectual property, and privacy. Economic issues including entrepreneurship and globalization.

Pre-requisites: C- or better in ECE 211 and ECE 212 and ECE 220
Typically offered in Fall and Spring

ECE 383 Introduction to Entrepreneurship and New Product Development (1 credit hours)
This course is part of the Engineering Entrepreneurs Program. Students work as team members on projects being led by seniors completing their senior capstone design. Students will be exposed to many areas of product development and will assist in the design and implementation of the prototype product.

Typically offered in Fall and Spring

ECE 384 Practical Engineering Prototyping (3 credit hours)
This course will teach prototyping skills, standard tools, and best practices to convert a project concept into a functioning, verifiable prototype. Course topics include understanding component specifications, system schematics, system functionality verification, power calculations and measurements, driver circuit designs, soldering and wiring procedures, basic MCU programming, Printed Circuit Board design and test, and debugging/test/verification tools/methods and procedures. Quick workshops on sensor interfacing, standard circuits and off-the-shelf systems, mobile app design, prototype packaging, and patent search resources will also be included in this course. Students will be required to complete several prototyping activities outside of class. This course is an open elective recommended to be taken before or at the same time as the capstone classes for Electrical and Computer (ECE) Engineering. Students are expected to have some basic knowledge about what is ac-dc, dc-dc voltage converters, motors, transistors, op-amps, and MOSFETS.

Prerequisites: (ECE 200 and ECE 209 and ECE 211) or their equivalent
Typically offered in Spring only

ECE 398 Special Projects in ECE (1-4 credit hours)
Faculty-supervised special projects in electrical and/or computer engineering. Projects involve small groups of students, working collaboratively or independently, focused on a single theme, such as the design of a component or system. Requires a "Course Agreement for Students Enrolled in Non-Standard Courses," completed by the student and faculty member prior to registration by the department.

C: ECE 301 or ECE 302 or ECE 303 or or E 304 or ECE 305 or ECE 306 or ECE 308 or ECE 309 or ECE 310; R: EE and CPE majors
Typically offered in Fall, Spring, and Summer

ECE 402 Communications Engineering (3 credit hours)
An overview of digital communications for wireline and wireless channels which focuses on reliable data transmission in the presence of bandwidth constraints and noise. The emphasis is on the unifying principles common to all communications systems, examples include digital telephony, compact discs, high-speed modems and satellite communications.

P: ECE 301 and ST 371; R: EE and CPE Majors Only
Typically offered in Fall, Spring, and Summer

ECE 403 Electronics Engineering (3 credit hours)
Design and analysis of CMOS integrated circuits, from single transistor stages to operational amplifiers. Feedback in operational amplifier circuits, compensation and stability. ECE majors only.

Prerequisite: ECE 301, ECE 302
Typically offered in Spring only

ECE 404 Introduction to Solid-State Devices (3 credit hours)
Basic principles required to understand the operation of solid-state devices. Semiconductor device equations developed from fundamental concepts. P-N junction theory developed and applied to the analysis of devices such as varactors, detectors, solar cells, bipolar transistors, field-effect transistors. Emphasis on device physics rather than circuit applications.

P: ECE 302 or E 304; C: EE, CPE, NanoScience and Technology Majors Only
Typically offered in Fall and Spring

ECE 406/CSC 406/CSC 506/ECE 506 Architecture Of Parallel Computers (3 credit hours)
The need for parallel and massively parallel computers. Taxonomy of parallel computer architecture, and programming models for parallel architectures. Example parallel algorithms. Shared-memory vs. distributed-memory architectures. Correctness and performance issues. Cache coherence and memory consistency. Bus-based and scalable directory-based multiprocessors. Interconnection-network topologies and switch design. Brief overview of advanced topics such as multiprocessor prefetching and speculative parallel execution. Credit is not allowed for more than one course in this set: ECE 406, ECE 506, CSC 406.

Typically offered in Fall and Spring

ECE 407 Introduction to Computer Networking (3 credit hours)
This course focuses on engineering principles of computer communications and networking, including layering concepts, overview of protocols, architectures for local, metropolitan, and wide-area networks, routing protocols, internet operations, transport control and applications, emerging issues in computer networks. EE and CPE majors only.

Prerequisite: ECE 301 or ECE 309
Typically offered in Fall and Spring

ECE 410/ECE 510 Introduction to Signal Processing (3 credit hours)
Concepts of digital signal processing: Discrete-Time Signals and Systems, Z-Transform, Frequency Analysis of Signals and Systems, Digital Filter Design, Analog-to-Digital and Digital-to-Analog Conversion, and the Discrete Fourier Transform.

Prerequisite: ECE 301
Typically offered in Fall and Spring

ECE 411 Introduction to Machine Learning (3 credit hours)
Learning from experience is one of the hallmarks of intelligence. Machine learning is the study of computer algorithms that improve automatically through experience. Machine learning, a subfield of artificial intelligence (AI), has achieved remarkable progress over the past decade, especially in deep learning. This course introduces fundamental concepts and algorithms that are vital for understanding state-of-the-art and cutting-edge development toward the next wave of AI. This course also exposes students to real-world applications via well-guided homework programming problems, as well as group projects. Topics include, but are not limited to optimization, linear statistical models, kernel regression, support vector machines, boosting machines, and deep neural networks.

P: (ECE 301 or ISE 361 or MA 341 or CSC 316) and (ST 370 or ST 371)
R: Students may not receive credit for both CSC 422 and ECE 411.
Typically offered in Fall only

ECE 418/BME 418/BME 518/ECE 518 Wearable Biosensors and Microsystems (3 credit hours)
This course surveys the methods and application of wearable electronics and microsystems to monitor human biometrics, physiology, and environmental conditions. Topics covered include wearable electrocardiograms, blood-glucose monitors, electronic tattoos, wearable energy harvesting, "smart" clothing, body area networks, and distributed population networks. Critical comparison of different sensor modalities, quantitative metrics, and how their limitations in realistic applications define the selection, design, and operation criteria of one type of sensor over another will be considered.

Prerequisite: Senior standing
Typically offered in Fall only

ECE 420 Wireless Communication Systems (3 credit hours)
A study of applications of communication theory and signal processing to wireless systems. Topics include an introduction to information theory and coding, basics and channel models for wireless communications, and some important wireless communication techniques including spread-spectrum and OFDM. MATLAB exercises expose students to engineering considerations.

Prerequisite: ECE 402
Typically offered in Spring only

ECE 422 Transmission Lines and Antennas for Wireless (3 credit hours)
Review of time-varying electromagnetic theory. A study of the analytical techniques and the characteristics of several useful transmission lines and antennas. Examples are coaxial lines, waveguides, microstrip, optical fibers and dipole, monopole and array antennas.

Prerequisite: ECE 303
Typically offered in Fall only

ECE 423 Introduction to Photonics and Optical Communications (3 credit hours)
This course investigates photonic devices at the component level and examines the generation, propagation, and detection of light in the context of optical communication systems. Topics include the design of simple optical systems and focuses on the use of lasers, fiber optics, and photodetectors. The labs include building a Michelson interferometer, preparing and coupling light to an optical fiber, characterizing LEDs and laser diodes and making a fiber optical link.

Typically offered in Fall only

ECE 424/ECE 524 Radio System Design (3 credit hours)
Introduction to communication theory and radio system design. Design and analysis of radio systems, such as heterodyne transceivers, and effects of noise and nonlinearity. Design and analysis of radio circuits: amplifiers, filters, mixers, baluns and other transmission line and discrete circuits.

Prerequisite: ECE 302
Typically offered in Spring only

ECE 426 Analog Electronics Laboratory (3 credit hours)
A hands on laboratory based course with two construction projects (dual power supply, high frequency buffer amplifier) and six breadboard based activities with a focus on operational amplifiers and their applications. Student must have a portable computer and 'Digilent Analog Discovery'. Topics include: amplifier performance, integrator/differentiator, filters, converters (I to V, V to I) and audio circuits.

Prerequisite: ECE 302
Typically offered in Fall and Spring

ECE 434 Fundamentals of Power Electronics (3 credit hours)
Design, analysis, modeling and control of DC-DC converters, DC-AC inverters, AC-DC rectifiers/converters, and AC-to-AC converters. power conversion using switched high-voltage high-current semiconductors in combination with inductors and capacitors. Design of DC-DC, DC-AC, AC-DC, and AC-AC power converters as well as an introductions to design of magnetic components for use in power converters, apllications to fuel cells, photovoltaics, motor drives, and uninterruptable power supplies

Prerequisite:ECE 302 or equivalent
Typically offered in Fall only

ECE 436 Digital Control Systems (3 credit hours)
Discrete system dynamics, sampled-data systems, mathematical representations of analog/digital and digital/analog conversions, open- and -closed-loop systems, input-output relationships, state-space and stability analyses, time and frequency domain analysis with emphasis on time domain. Design and implementation of digital controllers. Design project including hardware implementation.

Prerequisite: ECE 308
Typically offered in Spring only

ECE 442 Integrated Circuit Technology and Fabrication (3 credit hours)
Semiconductor device and integrated-circuit processing and technology. Wafer specification and preparation, oxidation, diffusion, ion implantation, photolithography, design rules and measurement techniques.

Prerequisite: ECE 404
Typically offered in Fall only

ECE 448/ECE 548 Python in ECE (3 credit hours)
The course provides broad exposure to Python programming to solve ECE-related problems. Course topics include basic mathematical operations, string /array operations, lists, functions, standard libraries in Python, files/folder operations, extracting and parsing data, data visualization techniques (graphs, tables, charts), and interfacing basic hardware such as sensors and microcontrollers for data collection and storage. The course will also have an introduction to the Python OpenCV library for computer vision, networking socket libraries, and machine learning libraries. Thus, the course is mainly designed for Electrical and Computer Engineering students at an advanced level of programming knowledge, not an introductory level of programming, and will differ from other programming and Python classes due to topics in hardware interfacing and Computer Vision. Please see a detailed list of topics and learning outcomes to know more about the course.

Typically offered in Summer only

ECE 451 Power System Analysis (3 credit hours)
Long-distance transmission of electric power with emphasis on load flow, economic dispatch, fault calculations and system stability. Applications of digital computers to power-system problems. Major design project.

Prerequisite: ECE 305
Typically offered in Fall only

ECE 452/ECE 552 Renewable Electric Energy Systems (3 credit hours)
Principles and characteristics of renewable energy based electric power generation technologies such as photovoltaic systems, wind turbines, and fuel cells. Main system design issues. Integration of these energy sources into the power grid. Economics of distributed generation. Credit is not allowed for both ECE 452 and ECE 552.

Prerequisite: ECE 305 or ECE 331
Typically offered in Spring only

ECE 453 Electric Motor Drives (3 credit hours)
Principles of electromechanical energy conversion; analysis, modeling, and control of electric machinery; steady state performance characteristics of direct-current, induction, synchronous and reluctance machines; scalar control of induction machines; introduction to direct- and quadrature-axis theory; dynamic models of induction and synchronous motors; vector control of induction and synchronous motors.

Prerequisite: A grade of C or better in ECE 305.
Typically offered in Spring only

ECE 455 Industrial Robotic Systems (3 credit hours)
Techniques of computer control of industrial robots: interfacing with synchronous hardware including analog/digital and digital/analog converters, interfacing noise problems, control of electric and hydraulic actuators, kinematics and kinetics of robots, path control, force control, sensing including vision. Major design project. EE, CPE, BME, JEM majors only.

Prerequisite: ECE 308
Typically offered in Fall only

ECE 456/ECE 556 Mechatronics (3 credit hours)
The study of electro-mechanical systems controlled by microcomputer technology. The theory, design and construction of smart systems; closely coupled and fully integrated products and systems. The synergistic integration of mechanisms, materials, sensors, interfaces, actuators, microcomputers, controllers, and information technology.

Prerequisite: ECE 308
Typically offered in Fall only

ECE 460/ECE 560 Embedded System Architectures (3 credit hours)
Concepts of architectures for embedded computing systems. Emphasis on hands-on implementation. CPU scheduling approaches to support multithreaded programs, including interrupts, cooperative schedulers, state machines, and preemptive scheduler (real-time kernel). Communication and synchronization between threads. Basic real-time analysis. Using hardware peripherals to replace software. Architectures and design patterns for digital control, streaming data, message parsing, user interfaces, low power, low energy, and dependability. Software engineering concepts for embedded systems. Students may not receive credit for both ECE 460 and ECE 560.

Prerequisite: C- or better in ECE 306
Typically offered in Fall only

ECE 461/ECE 561 Embedded System Design (3 credit hours)
Design and implementation of software for embedded computer systems. The students will learn to design systems using microcontrollers, C and assembly programming, real-time methods,Â computerÂ architecture, interfacing system development and communication networks.Â System performance is measured in terms of power consumption, speed and reliability. Efficient methods for project development and testing are emphasized. Credit will not be awarded for both ECE 461 and ECE 561. Restricted to CPE and EE Majors.

Prerequisite: Grade of C- or better in ECE 460
Typically offered in Spring only

ECE 463/ECE 563 Microprocessor Architecture (3 credit hours)
Architecture of microprocessors. Measuring performance. Instruction-set architectures. Memory hierarchies, including caches, prefetching, program transformations for optimizing caches, and virtual memory. Processor architecture, including pipelining, hazards, branch prediction, static and dynamic scheduling, instruction-level parallelism, superscalar, and VLIW. Major projects.

Prerequisite: ECE 209 and ECE 212
Typically offered in Fall and Spring

ECE 464/ECE 564 ASIC and FPGA Design with Verilog (3 credit hours)
Design of digital application specific integrated circuits (ASICs) and Field Programmable Gate Arrays (FPGAs) based on hardware description languages (Verilog) and CAD tools. Emphasis on design practices and underlying methods. Introduction to ASIC specific design issues including verification, design for test, low power design and interfacing with memories. Required design project. Expected Prior Experience or Background: ECE 310 is useful but not assumed. Functionally, I assume that students are familiar with logic design, including combinational logic gates, sequential logic gates, timing design, Finite State Machines, etc.

P: Grade of C or better in ECE 212 or equivalent.
Typically offered in Fall only

ECE 465/ECE 565 Operating Systems Design (3 credit hours)
The course explores basic concepts and mechanisms related to the design of modern operating systems, including: process scheduling and coordination, memory management, synchronization, storage, file systems, security and protection, and their application to multi-core and many-core processors. The course involves coding projects requiring strong C programming skills.

Prerequisite: ECE306 or CSC246; ECE309; Restrictions: ECE465, ECE565 and CSC501 are mutually exclusive: students may not receive credit for both ECE465 and ECE565, or both ECE465 and CSC501, or both ECE565 and CSC501
Typically offered in Fall only

ECE 466/ECE 566 Compiler Optimization and Scheduling (3 credit hours)
Provide insight into current compiler designs dealing with present and future generations of high performance processors and embedded systems. Introduce basic concepts in scanning and parsing. Investigate in depth program representation, dataflow analysis, scalar optimization, memory disambiguation, and interprocedural optimizations. Examine hardware/software tade-offs in the design of high performance processors, in particular VLIW versus dynamically scheduled architectures. Investigate back-end code generation techniques related to instruction selection, instruction scheduling for local, cyclic and global acyclic code, and register allocation and its interactions with scheduling and optimization.

Prerequisites: ECE 209 or competency in any machine language programming and ECE 309 or CSC 316 or proficiency in either C or C++ programming using advanced data structures, like hash tables and linked lists.P: ECE 209 or competency in an
Typically offered in Spring only

ECE 468/CHE 468/CHE 568/ECE 568 Conventional and Emerging Nanomanufacturing Techniques and Their Applications in Nanosystems (3 credit hours)
Conventional and emerging nano-manufacturing techniques and their applications in the fabrication of various structures and devices. Review of techniques for patterning, deposition, and etching of thin films including emerging techniques such as an imprint and soft lithography and other unconventional techniques. Electronic and mechanical properties of 0 to 3-D nanostructures and their applications in nano-electronics, MEMS/NEMS devices, sensing, energy harvesting, storage, flexible electronics and nano-medicine. Credit for both ECE/CHE 468 and ECE/CHE 568 is not allowed.

Prerequisite: E 304
Typically offered in Fall only

ECE 469/CSC 469 Quantum Programming (3 credit hours)
Introduction to programming for quantum computers. Introduction to the gate-level model of quantum computing, including quantum bits (qubits) and quantum information. Manipulation of quantum states using gates, circuits, and algorithms. Exploration of problems for which quantum computing provides an advantage over classical computing.

Prerequisite: CSC 316 or ECE 309
Typically offered in Spring only

ECE 470 Internetworking (3 credit hours)
Introduction, Planning and Managing networking projects, networking elements-hardware, software, protocols, applications; TCP/IP, ATM, LAN emulation. Design and implementation of networks, measuring and assuring network and application performance;metrics, tools, quality of service. Network-based applications, Network management and security.

Prerequisite: ECE 407 or CSC 401
Typically offered in Spring only

ECE 482/MAE 482 Engineering Entrepreneurship and New Product Development I (3 credit hours)
Applications of engineering, mathematics, basic sciences, finance, and business to the design and development of prototype engineering products. This course requires a complete written report and an end-of-course presentation. This is the first course in a two semester sequence. Students taking this course will implement their designed prototype in ECE 483: Senior Design Project in Electrical Engineering and Computer Engineering II-Engineering Entrepreneurs. Departmental approval required.

Typically offered in Fall and Spring

ECE 483/MAE 483 Engineering Entrepreneurship Senior Design II (3 credit hours)
Applications of engineering, science, management and entrepreneurship to the design, development and prototyping of new product ideas. Based on their own new product ideas, or those of others, students form and lead entrepreneurship teams (eTeams) to prototype these ideas. The students run their eTeams as 'virtual' startup companies where the seniors take on the executive roles. Joining them are students from other grade levels and disciplines throughout the university that agree to participate as eTeam members. Departmental approval required.

Prerequisite: ECE 482
Typically offered in Fall and Spring

ECE 484 Electrical and Computer Engineering Senior Design I (3 credit hours)
Applications of engineering and basic sciences to the total design of electrical and/or computer engineering circuits and systems. Consideration of the design process including concept and feasibility study, systems design, detailed design, project management, cost-effectiveness, along with development and evaluation of a prototype accomplished through design-team project activity. Supported with an introduction of key factors impacting the engineering design process including industrial design, finance, operations, etc. EE and CPE Majors only.

CPE major: Prerequisites: (ECE301 or ECE302) and (two of ECE306, ECE309, ECE310); Corequisite: One CPE Elective; EE major: Prerequisites: ECE301 and ECE302 and (one of ECE 303, E 304, ECE 305, 306, 308, 310); Corequisite: One EE Elective.
Typically offered in Fall only

ECE 485 Electrical and Computer Engineering Senior Design II (3 credit hours)
Applications of engineering and basic sciences to the total design of electrical engineering circuits and systems. Consideration of the design process including feasibility study, preliminary design detail, cost-effectiveness, along with development and evaluation of a prototype accomplished through design-team project activity. Complete written and oral engineering report required. EE and CPE majors only.

Prerequisite: ECE 484
Typically offered in Fall and Spring

ECE 488/PB 588/ECE 588/PB 488 Systems Biology Modeling of Plant Regulation (3 credit hours)
This course provides an introduction to the field of systems biology with a focus on mathematical modeling, gene regulatory network and metabolic pathway reconstruction in plants. Students will learn how to integrate biological data with mathematical, statistical, and computational approaches to gain new insights into structure and behavior of complex cellular systems. Students are expected to have a minimal background in calculus and basic biology. The course will build on these basic concepts and provide all students, regardless of background or home department, with the fundamental biology, mathematics, and computing knowledge needed to address systems biology problems.

Prerequisite: MA 131 or MA 141
Typically offered in Fall only

ECE 489/ECE 589/MSE 489/MSE 589/PY 489/PY 589 Solid State Solar and Thermal Energy Harvesting (3 credit hours)
This course studies the fundamental and recent advances of energy harvesting from two of the most abundant sources, namely solar and thermal energies. The first part of the course focuses on photovoltaic science and technology. The characteristics and design of common types of solar cells is discussed, and the known approaches to increasing solar cell efficiency will be introduced. After the review of the physics of solar cells, we will discuss advanced topics and recent progresses in solar cell technology. The second part of the course is focused on thermoelectric effect. The basic physical properties, Seebeck coefficient, electrical and thermal conductivities, are discussed and analyzed through the Boltzmann transport formalism. Advanced subject such as carrier scattering time approximations in relation to dimensionality and the density of states are studied. Different approaches for further increasing efficiencies are discussed including energy filtering, quantum confinement, size effects, band structure engineering, and phonon confinement.

P: ECE 302 or E 304 or MSE 355 or PY 407
Typically offered in Spring only

ECE 492 Special Topics in Electrical and Computer Engineering (1-4 credit hours)
Offered as needed for development of new courses in electrical and computer engineering.

Typically offered in Fall and Spring

ECE 495 Individual Study in ECE (1-3 credit hours)
Independent investigation of a topic or research problem under faculty supervision. Individualized/Independent Study and Research courses require a "Course Agreement for Students Enrolled in Non-Standard Courses" be completed by the student and faculty member prior to registration by the department.

P: Appropriate 300-level Course; R: EE and CPE Majors Only. Department Approval Required
Typically offered in Fall, Spring, and Summer

ECE 498 Special Projects in ECE (1-3 credit hours)
Faculty-supervised special projects in electrical and/or computer engineering. Projects involve small groups of students, working collaboratively or independently, focused on a single theme, such as the design of a component or system. Requires a "Course Agreement for Students Enrolled in Non-Standard Courses," completed by the student and faculty member prior to registration by the department.

Prerequisite: At least one 300-level ECE course, 3.0 GPA; Restricted to: EE or CPE majors
Typically offered in Fall, Spring, and Summer

ECE 505 Neural Interface Engineering (3 credit hours)
This course investigates the engineering techniques to understand, repair, replace, or enhance neural systems. The topics to be covered includes the following: the history of bioelectricity phenomena, the basics of modern neuroscience in electrical engineering terms and models, design of functional electrical interfaces with the nervous system for stimulating and recording purposes, basics of electrochemistry development of various systems for neuroprosthetics and neurorobotics applications such as pacemakers, cochlear implants and neuroprosthetic limbs.

Senior or graduate standing.
Typically offered in Fall only

ECE 506/ECE 406/CSC 406/CSC 506 Architecture Of Parallel Computers (3 credit hours)
The need for parallel and massively parallel computers. Taxonomy of parallel computer architecture, and programming models for parallel architectures. Example parallel algorithms. Shared-memory vs. distributed-memory architectures. Correctness and performance issues. Cache coherence and memory consistency. Bus-based and scalable directory-based multiprocessors. Interconnection-network topologies and switch design. Brief overview of advanced topics such as multiprocessor prefetching and speculative parallel execution. Credit is not allowed for more than one course in this set: ECE 406, ECE 506, CSC 406.

Typically offered in Fall, Spring, and Summer

ECE 510/ECE 410 Introduction to Signal Processing (3 credit hours)
Concepts of digital signal processing: Discrete-Time Signals and Systems, Z-Transform, Frequency Analysis of Signals and Systems, Digital Filter Design, Analog-to-Digital and Digital-to-Analog Conversion, and the Discrete Fourier Transform.

Prerequisite: ECE 301
Typically offered in Fall and Spring

ECE 511 Analog Electronics (3 credit hours)
Analog integrated circuits and analog integrated circuit design techniques. Review of basic device and technology issues Comprehensive coverage of MOS and Bipolar operational amplifiers. Brief coverage of analog-to-digital conversion techniques and switched-capacitor filters. Strong emphasis on use of computer modeling and simulation as design tool. Students required to complete an independent design project.

Prerequisite: ECE403
Typically offered in Fall only

ECE 512 Data Science from a Signal Processing Perspective (3 credit hours)
Topics covered will include modeling by minimum description length, scientific programming, optimization, machine learning basics, sparse signal processing, and dimensionality reduction.

P: ECE 301 or equivalent (Fourier transforms), ECE 410 or 510 (analog to digital conversion, filters), probability, linear algebra, calculus.
Typically offered in Fall only

ECE 514 Random Processes (3 credit hours)
Probabilistic descriptions of signals and noise, including joint, marginal and conditional densities, autocorrelation, cross-correlation and power spectral density. Linear and nonlinear transformations. Linear least-squares estimation. Signal detection.

Prerequisite: Statistics 371; Signals and Linear Systems; Linear Algebra; Calculus
Typically offered in Fall only

ECE 515 Digital Communications (3 credit hours)
This course is a first graduate-level course in digital communications. Functions and interdependence of various components of digital communication systems will be discussed. Statistical channel modeling, modulation and demodulation techniques, optimal receiver design, performance analysis methods, source coding, quantization, and fundamentals of information theory will be covered in this course.

Prerequisite: ECE 514, ST 371, Signals and Linear Systems; Linear Algebra
Typically offered in Spring and Summer

ECE 516 System Control Engineering (3 credit hours)
Introduction to analysis and design of continuous and discrete-time dynamical control systems. Emphasis on linear, single-input, single-output systems using state variable and transfer function methods. Open and closed-loop representation; analog and digital simulation; time and frequency response; stability by Routh-Hurwitz, Nyquist and Liapunov methods; performance specifications; cascade and state variable compensation. Assignments utilize computer-aided analysis and design programs.

Prerequisite: ECE 435 or ECE 301
Typically offered in Spring only

ECE 517/CSC 517 Object-Oriented Design and Development (3 credit hours)
The design of object-oriented systems, using principles such as the GRASP principles, and methodologies such as CRC cards and the Unified Modeling Language (ULM). Requirements analysis. Design patterns Agile Methods. Static vs. dynamic typing. Metaprogramming. Open-source development practices and tools. Test-first development. Project required, involving contributions to an open-source software project.

Prerequisite: CSC 326 or ECE 309
Typically offered in Fall and Spring

ECE 518/ECE 418/BME 418/BME 518 Wearable Biosensors and Microsystems (3 credit hours)
This course surveys the methods and application of wearable electronics and microsystems to monitor human biometrics, physiology, and environmental conditions. Topics covered include wearable electrocardiograms, blood-glucose monitors, electronic tattoos, wearable energy harvesting, "smart" clothing, body area networks, and distributed population networks. Critical comparison of different sensor modalities, quantitative metrics, and how their limitations in realistic applications define the selection, design, and operation criteria of one type of sensor over another will be considered.

Prerequisite: Senior standing
Typically offered in Fall only

ECE 522/BME 522 Medical Instrumentation (3 credit hours)
Fundamentals of medical instrumentation systems, sensors, and biomedical signal processing. Example instruments for cardiovascular and respiratory assessment. Clinical laboratory measurements, theraputic and prosthetic devices, and electrical safetyrequirements. Students should have background in electronics design using operational amplifiers.

Typically offered in Spring only

ECE 523 Photonics and Optical Communications (3 credit hours)
This course investigates photonic devices at the component level and examines the generation, propagation and detection of light in the context of optical communication systems. Topics include planar and cylindrical optical waveguides, LEDs, lasers,optical amplifiers, integrated optical and photodetectors, design tradeoffs for optical systems, passive optical networks, and wavelength division multiplexed systems.

Prerequisite: Graduate standing or Senior standing ; Engineering Majors or Physics Majors
Typically offered in Spring only

ECE 524/ECE 424 Radio System Design (3 credit hours)
Introduction to communication theory and radio system design. Design and analysis of radio systems, such as heterodyne transceivers, and effects of noise and nonlinearity. Design and analysis of radio circuits: amplifiers, filters, mixers, baluns and other transmission line and discrete circuits.

Prerequisite: ECE 302
Typically offered in Spring only

ECE 529 Semiconductor Optoelectronic Devices (3 credit hours)
This course explores the theory and operational characteristics of semiconductor optoelectronic devices. It broadly covers the fundamentals of the propagation, modulation, generation, and absorption of light in semiconductors. Topics include the energy transfer between photons and electrons/holes, light emission and absorption, radiative and non-radiative processes, electrical and optical characteristics, semiconductor materials, heterojunctions, and light extraction and trapping. Specific devices that are discussed include laser diodes, light-emitting diodes, electroabsorption modulators, photodetectors, and solar cells.

Prerequisite: ECE 302 and ECE 404 or equivalent; knowledge of programming and plotting software such as MATLAB, Python, or Excel
Typically offered in Spring only

ECE 530 Physical Electronics (3 credit hours)
Properties of charged particles under influence of fields and in solid materials. Quantum mechanics, particle statistics, semi-conductor properties, fundamental particle transport properties, p-n junctions.

Prerequisite: ECE 303, B average in ECE and MA
Typically offered in Fall only

ECE 533 Power Electronics Design & Packaging (3 credit hours)
This course introduces design of high-performance power electronic circuits where the integrated physical topology must be considered as part of the circuit, and provides an understanding of the multitude of parasitic elements created by circuit layout, materials and fabrication techniques. This prepares the student for high-density, high-frequency design of converters, gate drive circuits and resonant topologies. The student is also introduced to a power-electronics packaging lab and primary fabrication processes, such as Direct Bonded Copper (DBC) module construction with heavy-wire bonding, two-sided and 3D power modules in layered polymers, and high-voltage isolation of circuits with encapsulate in modules.

Prerequisite: ECE 434 or with permission of instructor
Typically offered in Spring only

ECE 534 Power Electronics (3 credit hours)
DC and AC analysis of isolated and non-isolated switch mode power supply. Basic converter topologies covered include: buck, boost and buck/boost and their transformer-couples derivatives. Design of close loop of these DC/DC converters. Power devices and their applications in DC/DC converters. Inductor and transformer design.

Prerequisite: ECE 302
Typically offered in Fall only

ECE 535/MAE 535 Design of Electromechanical Systems (3 credit hours)
A practical introduction to electromechanical systems with emphasis on modeling, analysis, design, and control techniques. Provides theory and practical tools for the design of electric machines (standard motors, linear actuators, magnetic bearings, etc). Involves some self-directed laboratory work and culuminates in an industrial design project. Topics include Maxwell's equations, electromechanical energy conversion, finite element analysis, design and control techniques.

Prerequisite: MA 341
Typically offered in Spring and Summer

ECE 536 Digital Control System Projects (3 credit hours)
Discrete system dynamics, sampled-data systems, mathematical representations of analog/digital and digital/analog conversions, open- and -closed-loop systems, input-output relationships, state-space and stability analyses, time and frequency domain analysis with emphasis on time domain. Design and implementation of digital controllers. Case studies. Design project including hardware implementation.

Prerequisite: Graduate standing & ECE 436 or similar or consent of instructor
Typically offered in Fall only

ECE 538 Integrated Circuits Technology and Fabrication (3 credit hours)
Processes used in fabrication of modern integrated circuits. Process steps for crystal growth, oxidation, diffusion, ion implantation, lithography, chemical vapor deposition, etching, metallization, layout and packaging. Process integration for MOS and biopolar processes. Characterization techniques, simulation, yield and reliability.

Prerequisite: ECE 404
Typically offered in Fall only

ECE 540 Electromagnetic Fields (3 credit hours)
Brief review of Maxwell's Equations, constitutive relations and boundary conditions. Reflection and refraction of plane waves; power and energy relations in isotropic media. Potential functions, Green's functions and their applications to radiation and scattering. Antenna fundamentals: linear antennas, uniform linear arrays and aperture antennas, microstrip antennas. Fundamentals of numerical methods for electromagnetic simulation and antenna design.

Prerequisite: ECE 422
Typically offered in Spring only

ECE 541 Antennas and Arrays (3 credit hours)
This course introduces theoretical and practical concepts for antennas and arrays. Students will learn antenna fundamentals and basic parameters, the relationships between radiation and vector potentials, and apply key electromagnetic theorems such as image theory and equivalence principle. The theory and design of linear antennas, aperture antennas, microstrip antennas are discussed. Radiation pattern control via phased arrays, reflectarrays, and periodic structures are studied. Students will learn CAD tools for electromagnetic design. This course assumes familiarity with Maxwell's equations, electromagnetic waves, electromagnetic theorems, and transmission line theory.

Prerequisite: ECE 422 or equivalent
Typically offered in Spring only

ECE 542/CSC 542 Neural Networks (3 credit hours)
Techniques for the design of neural networks for machine learning. An introduction to deep learning. Emphasis on theoretical and practical aspects including implementations using state-of-the-art software libraries. Requirement: Programming experience (an object-oriented language such as Python), linear algebra (MA 405 or equivalent), and basic probability and statistics.

Typically offered in Spring only

ECE 544 Design Of Electronic Packaging and Interconnects (3 credit hours)
A study of the design of digital and mixed signal interconnect and packaging. Topics covered include: Single chip (surface mount and through-hole) and multi-chip module packaging thecnology; packaging techology selection; thermal design; electricaldesign of printed circuit board, backplane and multi-chip module interconnect; receiver and driver selection; EMI control; CAD tools; and measurement issues.

Prerequisite: ECE 302
Typically offered in Spring only

ECE 546 VLSI Systems Design (3 credit hours)
Digital systems design in CMOS VLSI technology: CMOS devise physics, fabrication, primitive components, design and layout methodology, integrated system architectures, timing, testing future trends of VLSI technology.

Prerequisite: ECE 302
Typically offered in Spring only

ECE 547/CSC 547 Cloud Computing Technology (3 credit hours)
Study of cloud computing principles, architectures, and actual implementations. Students will learn how to critically evaluate cloud solutions, how to construct and secure a private cloud computing environment based on open source solutions, and how to federate it with external clouds. Performance, security, cost, usability, and utility of cloud computing solutions will be studied both theoretically and in hands-on exercises. Hardware-, infrastructure-, platform-, software-, security-, - "as-a-service".

Prerequisites: CSC 501 and either ECE/CSC 570 or ECE/CSC 573
Typically offered in Fall only

ECE 548/ECE 448 Python in ECE (3 credit hours)
The course provides broad exposure to Python programming to solve ECE-related problems. Course topics include basic mathematical operations, string /array operations, lists, functions, standard libraries in Python, files/folder operations, extracting and parsing data, data visualization techniques (graphs, tables, charts), and interfacing basic hardware such as sensors and microcontrollers for data collection and storage. The course will also have an introduction to the Python OpenCV library for computer vision, networking socket libraries, and machine learning libraries. Thus, the course is mainly designed for Electrical and Computer Engineering students at an advanced level of programming knowledge, not an introductory level of programming, and will differ from other programming and Python classes due to topics in hardware interfacing and Computer Vision. Please see a detailed list of topics and learning outcomes to know more about the course.

Typically offered in Summer only

ECE 549 RF Design for Wireless (3 credit hours)
Design of the hardware aspects of wireless systems with principle emphasis on design of radio frequency (RF) and microwave circuitry. Introduction of system concepts then functional block design of a wireless system. RF and microwave transistors, noise, power ampliefiers, CAE, linearization and antennas.

Prerequisite: ECE 303, ECE 302
Typically offered in Fall only

ECE 550 Power System Operation and Control (3 credit hours)
Fundamental concepts of economic operation and control of power systems. Real and reactive power balance. System components, characteristics and operation. Steady state and dynamic analysis of interconnected systems. Tieline power and load-frequencycontrol with integrated economic dispatch.

Prerequisite: ECE 305, ECE 435
Typically offered in Fall only

ECE 551 Smart Electric Power Distribution Systems (3 credit hours)
Features and components of electric power distribution systems, power flow, short circuit and reliability analysis, basic control and protection, communications and SCADA, new "smart" functionality such as integrated volt/var control, automated fault location isolation and restoration, demand response and advanced metering infrastructure, integration of distributed generation and energy storage.

Prerequisite: ECE 451
Typically offered in Spring only

ECE 552/ECE 452 Renewable Electric Energy Systems (3 credit hours)
Principles and characteristics of renewable energy based electric power generation technologies such as photovoltaic systems, wind turbines, and fuel cells. Main system design issues. Integration of these energy sources into the power grid. Economics of distributed generation. Credit is not allowed for both ECE 452 and ECE 552.

Prerequisite: ECE 305 or ECE 331
Typically offered in Spring only

ECE 553 Semiconductor Power Devices (3 credit hours)
The operational physics and design concepts for power semiconductor devices. Relevant transport properties of semiconductors. Design of breakdown voltage and edge terminations. Analysis of Schottky rectifiers, P-i-N rectifiers, Power MOSFETs, Bipolar Transistors, Thyristors and Insulated Gate Bipolar Transistors.

Prerequisite: ECE 404
Typically offered in Fall only

ECE 554 Electric Motor Drives (3 credit hours)
Topics covered in this course: Principles of Electromechanical energy conversion; analysis, modeling and control of electric machinery; steady state performance characteristics of direct current, induction, synchronous and reluctance machines; scalar control of induction machines; introduction to direct and quadrature axis theory; dynamic models of induction and synchronous machines; vector control of induction and synchronous machines.

Prerequisite: ECE 305 or equivalent
Typically offered in Spring only

ECE 555 Computer Control of Robots (3 credit hours)
An introduction to robotics: history and background, design, industrial applications and usage. Manipulator sensors, actuators and control, linear, non-linear, and force control. Manipulator kinematics: position and orientation, frame assignment, transformations, forward and inverse kinematics. Jacobian: velocities and static forces. Manipulator Kinetics: velocity, acceleration, force. Trajectory generation. Programming languages: manipulator level, task level, and object level. Introduction to advanced robotics. Credit not allowed for both ECE 455 and 555.

Prerequisite: ECE 435; ECE 436; ECE 456
Typically offered in Spring only

ECE 556/ECE 456 Mechatronics (3 credit hours)
The study of electro-mechanical systems controlled by microcomputer technology. The theory, design and construction of smart systems; closely coupled and fully integrated products and systems. The synergistic integration of mechanisms, materials, sensors, interfaces, actuators, microcomputers, controllers, and information technology.

Prerequisite: ECE 308
Typically offered in Fall only

ECE 557 Principles Of MOS Transistors (3 credit hours)
MOS capacitor and transistor regions of operation. Depletion and enhancement mode MOSFETs. MOSFET scaling, short and narrow channel effects. MOSFETs with ion-implanted channels. High field effects in MOSFETs with emphasis on recent advances in design of hit carrier suppressed structures. Small and large signal MOSFET models. State of the art in MOS process integration.

Prerequisite: ECE 404
Typically offered in Fall only

ECE 558 Digital Imaging Systems (3 credit hours)
Foundation for designing and using digital devices to accurately capture and display color images, spatial sampling, frequency analysis, quantization and noise characterization of images. Basics of color science are presented and applied to image capture and output devices.

Prerequisites: ECE 301 and ST 372
Typically offered in Fall only

ECE 560/ECE 460 Embedded System Architectures (3 credit hours)
Concepts of architectures for embedded computing systems. Emphasis on hands-on implementation. CPU scheduling approaches to support multithreaded programs, including interrupts, cooperative schedulers, state machines, and preemptive scheduler (real-time kernel). Communication and synchronization between threads. Basic real-time analysis. Using hardware peripherals to replace software. Architectures and design patterns for digital control, streaming data, message parsing, user interfaces, low power, low energy, and dependability. Software engineering concepts for embedded systems. Students may not receive credit for both ECE 460 and ECE 560.

Prerequisite: C- or better in ECE 306
Typically offered in Fall only

ECE 561/ECE 461 Embedded System Design (3 credit hours)
Design and implementation of software for embedded computer systems. The students will learn to design systems using microcontrollers, C and assembly programming, real-time methods,Â computerÂ architecture, interfacing system development and communication networks.Â System performance is measured in terms of power consumption, speed and reliability. Efficient methods for project development and testing are emphasized. Credit will not be awarded for both ECE 461 and ECE 561. Restricted to CPE and EE Majors.

Prerequisite: Grade of C- or better in ECE 460
Typically offered in Spring only

ECE 563/ECE 463 Microprocessor Architecture (3 credit hours)
Architecture of microprocessors. Measuring performance. Instruction-set architectures. Memory hierarchies, including caches, prefetching, program transformations for optimizing caches, and virtual memory. Processor architecture, including pipelining, hazards, branch prediction, static and dynamic scheduling, instruction-level parallelism, superscalar, and VLIW. Major projects.

Prerequisite: ECE 209 and ECE 212
Typically offered in Fall and Spring

ECE 564/ECE 464 ASIC and FPGA Design with Verilog (3 credit hours)
Design of digital application specific integrated circuits (ASICs) and Field Programmable Gate Arrays (FPGAs) based on hardware description languages (Verilog) and CAD tools. Emphasis on design practices and underlying methods. Introduction to ASIC specific design issues including verification, design for test, low power design and interfacing with memories. Required design project. Expected Prior Experience or Background: ECE 310 is useful but not assumed. Functionally, I assume that students are familiar with logic design, including combinational logic gates, sequential logic gates, timing design, Finite State Machines, etc.

P: Grade of C or better in ECE 212 or equivalent.
Typically offered in Fall only

ECE 565/ECE 465 Operating Systems Design (3 credit hours)
The course explores basic concepts and mechanisms related to the design of modern operating systems, including: process scheduling and coordination, memory management, synchronization, storage, file systems, security and protection, and their application to multi-core and many-core processors. The course involves coding projects requiring strong C programming skills.

Prerequisite: ECE306 or CSC246; ECE309; Restrictions: ECE465, ECE565 and CSC501 are mutually exclusive: students may not receive credit for both ECE465 and ECE565, or both ECE465 and CSC501, or both ECE565 and CSC501
Typically offered in Fall only

ECE 566/ECE 466 Compiler Optimization and Scheduling (3 credit hours)
Provide insight into current compiler designs dealing with present and future generations of high performance processors and embedded systems. Introduce basic concepts in scanning and parsing. Investigate in depth program representation, dataflow analysis, scalar optimization, memory disambiguation, and interprocedural optimizations. Examine hardware/software tade-offs in the design of high performance processors, in particular VLIW versus dynamically scheduled architectures. Investigate back-end code generation techniques related to instruction selection, instruction scheduling for local, cyclic and global acyclic code, and register allocation and its interactions with scheduling and optimization.

Prerequisites: ECE 209 or competency in any machine language programming and ECE 309 or CSC 316 or proficiency in either C or C++ programming using advanced data structures, like hash tables and linked lists.P: ECE 209 or competency in an
Typically offered in Spring only

ECE 568/ECE 468/CHE 468/CHE 568 Conventional and Emerging Nanomanufacturing Techniques and Their Applications in Nanosystems (3 credit hours)
Conventional and emerging nano-manufacturing techniques and their applications in the fabrication of various structures and devices. Review of techniques for patterning, deposition, and etching of thin films including emerging techniques such as an imprint and soft lithography and other unconventional techniques. Electronic and mechanical properties of 0 to 3-D nanostructures and their applications in nano-electronics, MEMS/NEMS devices, sensing, energy harvesting, storage, flexible electronics and nano-medicine. Credit for both ECE/CHE 468 and ECE/CHE 568 is not allowed.

Prerequisite: E 304
Typically offered in Fall only

ECE 569/CSC 569 Quantum Computing (3 credit hours)
This course provides an introduction to quantum computing. It will feature the three pillars, quantum system architectures, algorithms, and programming of quantum computing. Its focus is on the applicability of problems to quantum computing from a practical point of view, with only the necessary foundational coverage of the physics and theoretical aspects to understand quantum computing. Both simulation software and actual quantum computers will be utilized to prototype problem solutions. This should develop a better understanding of how problems are transformed into quantum algorithms and what programming language support is best suited for a given application area. The course will require significant background reading plus presentations, projects, and exercises per participant.

Prerequisite: Knowledge of Python programming and linear algebra
Typically offered in Fall only

ECE 570/CSC 570 Computer Networks (3 credit hours)
General introduction to computer networks. Discussion of protocol principles, local area and wide area networking, OSI stack, TCP/IP and quality of service principles. Detailed discussion of topics in medium access control, error control coding, and flow control mechanisms. Introduction to networking simulation, security, wireless and optical networking.

Prerequisite: ECE 206 or CSC 312, ST 371, CSC 258 and Senior standing or Graduate standing
Typically offered in Fall, Spring, and Summer

ECE 572/CSC 572 Optimizations and Algorithms (3 credit hours)
This course introduces advanced optimization theory and algorithms with rapidly growing applications in machine learning, systems, and control. Methods are given to obtain a non-dynamic system's extremum (minimum or maximum) and use these methods in various engineering applications. This course aims to prepare graduate students with a solid theoretical and mathematical foundation and applied techniques at the intersection of optimization, algorithms, and machine learning to conduct advanced research in related fields. Students will gain expertise in designing algorithms based on common techniques, dealing with intractable problems, and implementing algorithms given the description. Students must undertake a semester-long project (at Google Colab) that practices the optimization theory and algorithms in their areas of interest. These projects can replicate or improve a known solving strategy for a given optimization problem to assess and compare the performance.

Restriction: Introductory courses in probability and linear algebra and Graduate Student Standing
Typically offered in Fall only

ECE 573/CSC 573 Internet Protocols (3 credit hours)
Principles and issues underlying provision of wide area connectivity through interconnection of autonomous networks. Internet architecture and protocols today and likely evolution in future. Case studies of particular protocols to demonstrate how fundamental principles applied in practice. Selected examples of networked clinet/server applications to motivate the functional requirements of internetworking. Project required.

Prerequisite: CSC/ECE 570
Typically offered in Fall and Spring

ECE 574/CSC 574 Computer and Network Security (3 credit hours)
This course presents foundational concepts of computer and network security and privacy. It covers a wide breadth of concepts, including; Fundamentals of computer security and privacy, including security models, policies, and mechanisms; Cryptography for secure systems, including symmetric and asymmetric ciphers, hash functions, and integrity mechanisms; Authentication of users and computers; Network attacks and defenses at the network and application layers; Common software vulnerabilities and mitigation strategies; Secure operating systems and seminal access control models and policies; Principles of intrusion detection; Privacy, including considerations of end-user technologies.

Prerequisite: (CSC 316 or ECE309) and (CSC 401 or ECE407) or equivalent
Typically offered in Fall and Spring

ECE 575/CSC 575 Introduction to Wireless Networking (3 credit hours)
Introduction to cellular communications, wireless local area networks, ad-hoc and IP infrastructures. Topics include: cellular networks, mobility mannagement, connection admission control algorithms, mobility models, wireless IP networks, ad-hoc routing, sensor networks, quality of service, and wireless security.

Prerequisite: ECE/CSC 570
Typically offered in Spring only

ECE 576/CSC 576 Networking Services: QoS, Signaling, Processes (3 credit hours)
Topics related to networking services, signaling for setting up networking services, such as SIP and IMS, networking architectures for providing QoS for networking services, such as MPLS, DiffServ and RAC, signaling protocols for setting up QoS connections in the transport stratum, such as LDP and RSVP-TE, video-based communications, and capacity planning models for dimensioning services.

Prerequisite: CSC/ECE 570
Typically offered in Fall and Spring

ECE 577/CSC 577 Switched Network Management (3 credit hours)
Topics related to design and management of campus enterprise networks, including VLAN design; virtualization and automation methodologies for management; laboratory use of open space source and commercial tools for managing such networks.

Typically offered in Fall only

ECE 578/CSC 578 LTE and 5G Communications (3 credit hours)
The course provides an introduction to the theoretical fundamentals and practical/experimental aspects of Long Term Evolution (LTE) and 5G systems. A basic understanding of digital communications and radio access networks is required. Following topics will be studied: 1) User and control plane protocols, 2) physical layer for downlink, 3) physical layer for uplink, 4) practical deployment aspects, 5) LTE-Advanced, 6) 5G communications. Fundamental concepts to be covered in the context of LTE/5G systems include OFDMA/SC-FDMA, synchronization, channel estimation, link adaptation, MIMO, scheduling, and millimeter wave systems. Students are recommended to have the prior knowledge gained from ECE 570 or ECE 582 before taking this course. The course will also require using Matlab software for homeworks, including its LTE and 5G toolboxes.

Typically offered in Fall only

ECE 579/OR 579/CSC 579 Introduction to Computer Performance Modeling (3 credit hours)
Workload characterization, collection and analysis of performance data, instrumentation, tuning, analytic models including queuing network models and operational analysis, economic considerations.

Prerequisite: CSC 312 or ECE 206 and MA 421
Typically offered in Fall and Spring

ECE 581 Electric Power System Protection (3 credit hours)
Protection systems used to protect the equipment in an electric power system against faults, fault analysis methods, basic switchgear used for protection, basic protection schemes, such as overcurrent, differential, and distance protection and their application.

Prerequisite: ECE 451
Typically offered in Spring only

ECE 583 Electric Power Engineering Practicum I (3 credit hours)
This course introduces fundamentals of project management and system engineering principles in a wide range of electric power applications from concept through termination. The course also provides opportunities for students to adapt technical content to both expert and novice audiences in project management reports and presentations. Restricted to Master of Science in Electric Power Systems Engineering.

Prerequisite: ECE 451
Typically offered in Spring only

ECE 584 Electric Power Engineering Practicum II (3 credit hours)
In this capstone course students will apply electric engineering and science knowledge to an electrical power engineering project. Consideration of the design process including feasibility study, preliminary design detail, cost effectiveness, along with development and evaluation of a prototype accomplished through design-team project activity. Complete written and oral engineering report required. Restricted to Master of Science in Electric Power Systems Engineering.

Prerequisite: ECE 583
Typically offered in Fall and Summer

ECE 585 The Business of the Electric Utility Industry (3 credit hours)
Evolution of the electric utility industry, the structure and business models of the industry, the regulatory factors within which the utilities operate, the operations of the utility industry and the current policy and emerging technology issues facing the business. The course includes significant interaction with industry officials and utility business operations.

Prerequisite: ECE 451
Typically offered in Fall only

ECE 586 Communication and SCADA Systems for Smart Grid (3 credit hours)
This is an introductory course on communication technologies and SCADA (supervisory control and data acquisition) systems for smart electric power applications. The fundamental concepts, principles, and practice of how communication systems operate are introduced and the function of main components reviewed. Application of communication systems for electric power, in particular SCADA architecture and protocols are also introduced. The course includes hands-on experience with typical intelligent electronic devices interconnected by a communication system.

R: Graduate Students Only
Typically offered in Fall only

ECE 587 Power System Transients Analysis (3 credit hours)
Review of solutions to first and second order differential equations for electric power circuit transients. Applications to fault current instantaneous, shunt capacitor transients, circuit switching transients and overvoltages, current interruption and transformer transient behavior. Computer solution techniques for transient analysis using PSCAD and Matlab/Simulink. Modeling of utility power electronics circuits including single and three-phase rectifiers and inverters. Applications of power electronics for transmission system control and renewable generation. Distributed line modeling for traveling wave analysis of surge events. Introduction to voltage insulation, surge arrestor operation and lightning stroke analysis.

Typically offered in Fall only

ECE 588/PB 488/ECE 488/PB 588 Systems Biology Modeling of Plant Regulation (3 credit hours)
This course provides an introduction to the field of systems biology with a focus on mathematical modeling, gene regulatory network and metabolic pathway reconstruction in plants. Students will learn how to integrate biological data with mathematical, statistical, and computational approaches to gain new insights into structure and behavior of complex cellular systems. Students are expected to have a minimal background in calculus and basic biology. The course will build on these basic concepts and provide all students, regardless of background or home department, with the fundamental biology, mathematics, and computing knowledge needed to address systems biology problems.

Prerequisite: MA 131 or MA 141
Typically offered in Fall only

ECE 589/MSE 489/MSE 589/PY 489/PY 589/ECE 489 Solid State Solar and Thermal Energy Harvesting (3 credit hours)
This course studies the fundamental and recent advances of energy harvesting from two of the most abundant sources, namely solar and thermal energies. The first part of the course focuses on photovoltaic science and technology. The characteristics and design of common types of solar cells is discussed, and the known approaches to increasing solar cell efficiency will be introduced. After the review of the physics of solar cells, we will discuss advanced topics and recent progresses in solar cell technology. The second part of the course is focused on thermoelectric effect. The basic physical properties, Seebeck coefficient, electrical and thermal conductivities, are discussed and analyzed through the Boltzmann transport formalism. Advanced subject such as carrier scattering time approximations in relation to dimensionality and the density of states are studied. Different approaches for further increasing efficiencies are discussed including energy filtering, quantum confinement, size effects, band structure engineering, and phonon confinement.

P: ECE 302 or E 304 or MSE 355 or PY 407
Typically offered in Spring only

ECE 591 Special Topics In Electrical Engineering (1-6 credit hours)
Two-semester sequence to develop new courses and to allow qualified students to explore areas of special interest.

Prerequisite: B average in technical subjects
Typically offered in Fall and Spring

ECE 592 Special Topics In Electrical Engineering (1-6 credit hours)
Two-semester sequence to develop new courses and to allow qualified students to explore areas of special interest.

Prerequisite: B average in technical subjects
Typically offered in Fall and Spring

ECE 600 ECE Graduate Orientation (1 credit hours)
Introduction of the Electrical and Computer Engineering Department graduate program. Introduction to computing and library facilities; Review of NC State student code of conduct and ethics. Structure of the ECE department. General information for starting graduate studies. Overview of on-going research projects by faculty members. Must hold graduate standing.

Typically offered in Fall and Spring

ECE 633 Individual Topics In Electrical Engineering (1-3 credit hours)
Provision of opportunity for individual students to explore topics of special interest under direction of a member of faculty.

Prerequisite: B average in technical subjects
Typically offered in Fall and Spring

ECE 634 Individual Studies In Electrical Engineering (1-3 credit hours)
The study of advanced topics of special interest to individual students under direction of faculty members.

Prerequisite: Graduate standing
Typically offered in Fall, Spring, and Summer

ECE 640 Semiconductor Manufacturing Practicum I (3 credit hours)
This course on semiconductor manufacturing focuses on high-volume production, process optimization, automation, and yield improvement, distinct from semiconductor fabrication courses. It covers the full manufacturing pipeline--from wafer production and process integration to packaging, reliability, and cost optimization. Students will explore design for manufacturability (DFM), statistical process control (SPC), metrology, defect inspection, and smart manufacturing technologies such as AI-driven automation. Hands-on components include cleanroom process control (if available), semiconductor fab simulations, defect analysis, yield optimization exercises, packaging assembly, and failure analysis labs. The course concludes with an industry case study competition and a guest lecture from a semiconductor manufacturing expert, ensuring students gain both theoretical and practical insights into modern semiconductor manufacturing challenges and solutions.

Prerequisite: Graduate Standing
Typically offered in Summer only

ECE 641 Applications Engineering Using Wide Bandgap Semiconductors Practicum II (3 credit hours)
This practicum course on Application Engineering using Wide Bandgap (WBG) Semiconductors is a project-based, hands-on experience focused on real-world applications of SiC and GaN devices in power electronics, EVs, RF systems, and renewable energy. The first week covers mini-projects, including SiC/GaN device characterization, DC-DC converters, high-frequency inverters, EV fast chargers, and solar inverters. In the second week, students work in teams on a capstone project, selecting from high-efficiency EV drivetrain inverters, GaN-based 5G RF power amplifiers, or SiC-based bidirectional DC-DC converters. The course culminates in a final project showcase with industry expert feedback. Designed for senior undergraduates, graduate students, or industry professionals, this practicum provides cutting-edge skills in WBG semiconductor applications through hands-on labs, simulations, and prototype testing.

Prerequisite: Graduate Standing
Typically offered in Summer only

ECE 650 Internship (3 credit hours)
This course requires an internship with a company or organization outside the University. The student will secure an internship of a technical nature and complete and submit a Coop report for evaluation.

Restricted: 14EEMS, 14CPEMS, 14CNEMS, 14EPSEMS
Typically offered in Fall and Spring

ECE 675 Projects in Electrical and Computer Engineering (1-3 credit hours)
This course is for long-term projects supervised by ECE faculty for students to explore cutting-edge research in ECE.

R: Graduate Standing
Typically offered in Fall, Spring, and Summer

ECE 685 Master's Supervised Teaching (1-3 credit hours)
Teaching experience under the mentorship of faculty who assist the student in planning for the teaching assignment, observe and provide feedback to the student during the teaching assignment, and evaluate the student upon completion of the assignment.

Prerequisite: Master's student
Typically offered in Spring only

ECE 690 Master's Exam (1-9 credit hours)

ECE 693 Master's Supervised Research (1-9 credit hours)
Instruction in research and research under the mentorship of a member of the Graduate Faculty.

Prerequisite: Master's student
Typically offered in Fall only

ECE 695 Master's Thesis Research (1-9 credit hours)
Thesis research.

Prerequisite: Master's student
Typically offered in Fall, Spring, and Summer

ECE 696 Summer Thesis Research (1 credit hours)
For graduate students whose programs of work specify no formal course work during a summer session and who will be devoting full time to thesis research.

Prerequisite: Master's student
Typically offered in Summer only

ECE 699 Master's Thesis Preparation (1-9 credit hours)
For students who have completed all credit hour requirements and full-time enrollment for the master's degree and are writing and defending their thesis.

Prerequisite: Master's student
Typically offered in Fall and Spring

ECE 706 Advanced Parallel Computer Architecture (3 credit hours)
Advanced topics in parallel computer architecture. Hardware mechanisms for scalable cache coherence, synchronization, and speculation. Scalable systems and interconnection networks. Design or research project required.

Prerequisite: ECE/CSC 506, ECE 521
Typically offered in Spring only

ECE 710 Advanced Digital Signal Processing (3 credit hours)
Digital signal processing (DSP) fundamental concepts are reviewed, providing additional depth in certain areas. The following advanced DSP concepts are covered: digital filter design, sample rate conversion, filter banks, wavelets, power spectrum estimation, and adaptive filtering. Additional topics are introduced at the instructor's discretion.

Prerequisite: ECE 410 or ECE 510 or equivalent; though not required, a background in linear algebra (MA 305 or MA 405 or equivalent) and probability/random variables (ST 371 or ECE 514 or equivalent) is helpful
Typically offered in Spring only

ECE 712 Integrated Circuit Design for Wireless Communications (3 credit hours)
Analysis, simulation, and design of the key building blocks of an integrated radio: amplifiers, mixers, and oscillators. Topics include detailed noise optimization and linearity performance of high frequency integrated circuits for receivers and transmitters. Introduction to several important topics of radio design such as phase-locked loops, filters and large-signal amplifiers. Use of advanced RF integrated circuit simulation tools such as SpectreRF or ADS for class assignments.

Prerequisite: ECE 511
Typically offered in Spring only

ECE 714 Advanced Integrated Circuit Design: Data Converters (3 credit hours)
This course is a graduate level course in Analog-to-digital converters. Students will learn the fundamentals of sampling and the translation of signals form the digital to analog and analog to digital domains. Students will learn the basic circuits unique to data converters and how they impact design. Students will learn to a design digital-to-analog converter as well as 3 ADCs: Pipeline, Sigma-Delta and Successive-approximation. After completion of this course you will have the background to successfully design an ADC and DAC.

Prerequisite: ECE 511
Typically offered in Fall only

ECE 718 Computer-Aided Circuit Analysis (3 credit hours)
Steady state and transient analysis of circuits with emphasis on circuit theory and computer methods. Consideration of many analysis techniques, including linear nodal, signal flow graph, state equation, time-domain and functional simulation and analysis of sampled data systems. Sensitivity and tolerance analysis, macromodeling of large circuits and nonlinear circuit theory.

Prerequisite: ECE 511

ECE 719 Advanced Microwave Design (3 credit hours)
Development and examination of techniques used in the design of microwave and millimeter wave components and systems. Specific topics include frequency planning, system design using modules, and design of microwave amplifiers and oscillators. Design for specified frequency, noise, power, mixer or oscillator performance will be covered. There are three design projects: system planning, amplifier design, and oscillator design all using commercial microwave computer aided design tools.

Prerequisite: ECE 549
Typically offered in Spring only

ECE 720 Electronic System Level and Physical Design (3 credit hours)
Study of transaction-level modeling of digital systems-on-chip using SystemC. Simulation and analysis of performance in systems with distributed control. Synthesis of digital hardware from high-level descriptions. Physical design methodologies, including placement, routing, clock-tree insertion, timing, and power analysis. Significant project to design a core at system and physical levels. Knowledge of object-oriented programming with C and register-transfer-level design with verilog or VHDL is required.

Typically offered in Fall only

ECE 721 Advanced Microarchitecture (3 credit hours)
Survey of advanced computer microarchitecture concepts. Modern superscalar microarchitecture, complexity-effective processors, multithreading, advanced speculation techniques, fault-tolerant microarchitectures, power and energy management, impact of new technology on microarchitecture. Students build on a complex simulator which is the basis for independent research projects.

Prerequisite: ECE 521
Typically offered in Spring only
This course is offered alternate even years

ECE 722 Electronic Properties of Solid-State Materials (3 credit hours)
Materials and device-related electronic properties of semiconductors. Included topics: energy band structure, electrical and thermal transport phenomena, scattering processes, localized energy states, equilibrium and non-equilibrium semiconductor statistics.

Prerequisite: ECE 530
Typically offered in Spring only

ECE 723 Optical Properties Of Semiconductors (3 credit hours)
Materials and device-related properties of compound optical semiconductors. Included topics: band structure, heterojunctions and quantum wells, optical constants, waveguides and optical cavities, absorption and emission processes in semiconductors, photodetectors, light emitting diodes, semiconductor lasers.

Prerequisite: ECE 530
Typically offered in Spring only

ECE 724 Electronic Properties Of Solid-State Devices (3 credit hours)
Basic physical phenomena responsible for operation of solids-state devices. Examination and utilization of semiconductor transport equations to explain principles of device operation. Various solid-state electronics devices studied in detail.

Prerequisite: ECE 530
Typically offered in Spring only

ECE 725 Quantum Engineering (3 credit hours)
Development of advanced engineering concepts at the quantum level relevant to nanoscience, nanoelectronics, and quantum photonics. Topics include tunneling phenomena, specifics of time dependent and time independent perturbation methodology for addressing applications under consideration, including the WKB approach, and an introduction to second quantization for engineers. Applications include, but are not limited to, tunneling in a two-level system, molecular rotation through excitation, field emission, van der Waal interactions, optical absorption in quantum wells, and electron transport through model molecules.

Prerequisite: ECE 530, and PY 401
Typically offered in Spring only

ECE 726 Advanced Feedback Control (3 credit hours)
Advanced topics in dynamical systems and multivariable control. Current research and recent developments in the field.

Prerequisite: ECE 516
Typically offered in Fall only

ECE 732 Dynamics and Control of Electric Machines (3 credit hours)
Dynamic behavior of AC electric machines and drive systems; theory of field orientation and vector control for high performance induction and synchronous machines; permanent magnet and reluctance machines and their control; principles of voltage source and current source inverters, and voltage and current regulation methods.

Prerequisite: ECE 453 or ECE 592
Typically offered in Fall only

ECE 733 Digital Electronics (3 credit hours)
In-depth study of digital circuits at the transistor level. Topics include fundamentals; high speed circuit design; low-power design; RAM; digital transceivers; clock distribution; clock and data recovery; circuits based on emergining devices. Project.

Prerequisite: ECE 546
Typically offered in Fall only

ECE 734 Power Management Integrated Circuits (3 credit hours)
Review of modern power management converters and circuits; Review modeling and control of converters; Detail discussion of voltage and current mode controllers; Understanding of power converter losses and optimization method, as well as management of power; Integrated circuit design of various power management chips.

Prerequisite: ECE 511 and ECE 534
Typically offered in Spring only

ECE 735 Wide Band Gap Semiconductor Power Devices (3 credit hours)
This course provides students with an in-depth knowledge of power devices built from wide bandgap semiconductors: the design of high breakdown voltages, the physics of unique power rectifier structures suitable for SiC material, the operating principles for unique SiC power MOSFETs, and GaN HEMT devices, the development of bipolar power devices from SiC to achieve ultra-high voltage performance and the performance of wide bandgap semiconductor power devices as compared to advanced silicon devices.

Prerequisite: ECE 553 or equivalent
Typically offered in Spring only

ECE 736 Power System Stability and Control (3 credit hours)
Principles of FACTS (flexible AC transmission systems) and their applications. Power transmission on an AC system. Power system models for steady-state and dynamic analysis. Power system transient analysis for stability assessment. Voltage phenomena and methods for assessment.

Prerequisite: ECE 451 and ECE 750
Typically offered in Spring only

ECE 739 Integrated Circuits Technology and Fabrication Laboratory (3 credit hours)
An integrated circuit laboratory to serve as a companion to ECE 538. Hands-on experience in semiconductor fabrication laboratory. Topics include: techniques used to fabricate and electrically test discrete semiconductor devices, the effects of process variations on measurable parameters.

Prerequisite: ECE 538
Typically offered in Spring only

ECE 745 ASIC Verification (3 credit hours)
This course covers the verification process used in validating the functional correctness in today's complex ASICs (application specific integrated circuits). Topics include the fundamentals of simulation based functional verification, stimulus generation, results checking, coverage, debug, and formal verification. Provides the students with real world verification problems to allow them to apply what they learn.

Prerequisite: ECE 564
Typically offered in Spring only

ECE 748 Advanced Functional Verification with Universal Verification Methodology (3 credit hours)
The Universal Verification Methodology is the industry standard for functional verification of today's complex ASICs and FPGAs. Students will learn the content and use of UVM to architect and implement complex test benches. The characteristics and architecture of reusable verification components is a major focus of the course. Students will learn and implement verification components which are reusable across projects, from block level simulation to chip level simulation, and from simulation to emulation. The course projects teach and demonstrate advanced verification methodologies that prepare students for careers in functional verification of digital semiconductors.

Prerequisite: ECE 745 or equivalent
Typically offered in Fall only

ECE 751 Detection and Estimation Theory (3 credit hours)
Methods of detection and estimation theory as applied to communications, speech and image processing. Statistical description of signals and representation in time, spatial and frequency domains; Baysian methods, including Wiener, Kalman and MAP filters; performance measures; applications to both continuous and discrete systems.

Prerequisite: ECE 514, ECE 421
Typically offered in Spring only

ECE 752 Information Theory (3 credit hours)
An overview of Shannon's theory of information, which establishes fundamental limits on the performance of data compression and quantization algorithms, communication systems, and detection and estimation algorithms. Topics include information measures and their properties, information source models, lossless data compression, channel coding and capacity, information theory and statistics, and rate-distortion theory. Applications of information theory will also be discussed, including Lempel-Ziv data compression, vector quantization, error-correcting codes, satellite communications and high-speed modems.

Prerequisite: ECE 514: Random Processes

ECE 753 Computational Methods for Power Systems (3 credit hours)
This course is designed to introduce computational methods used for power grid operation and planning. The course will help students understand the various computational methods that form the basis of major commercial software packages used by grid analysts and operators. Students are expected to have some basic understanding of principles of power system analysis including power system models, power flow calculation, economic dispatch, reliable and stability analysis. The course covers the following computational methods commonly used in power grid operation and planning: Locational Marginal Pricing Schemes, Game Theory, Unconstrained Optimization, Linear Programming, Non-linear Constrained Optimization, and Forecasting Methods.

Prerequisite: ECE 451 or ECE 550
Typically offered in Spring only

ECE 755 Advanced Robotics (3 credit hours)
Advanced robotics at its highest level of abstraction; the level of synthesizing human reasoning and behavior. Advanced tobotics deals with the intelligent connection of perception to action. At this level the subject requires knowledge of sensing(computer vision, tactile, sonar), and reasoning (artifical intelligence: machine learning, planning, world modeling). The advanced robotics course will be valuable for students who wish to work in the area.

Prerequisite: ECE 555; MAE 544
Typically offered in Fall only

ECE 756 Advanced Mechatronics (3 credit hours)
A project-oriented course focusin on the design, analysis, and implementation of advanced mechatronics technologies, including large-scale distributed sensors, distributed-actuators, and distributed-controllers connected via communication networks.Will use unmanned vehicles as the project platform, with applications from sensors, actuators, network-based controllers, cameras, and microcontrollers. ECE 516 is recommended.

Prerequisite: ECE 456 or ECE 556 with a Grade B+ and above
Typically offered in Spring only

ECE 759 Pattern Recognition (3 credit hours)
Image pattern recognition techniques and computer-based methods for scene analysis, including discriminate functions, fixture extraction, classification strategies, clustering and discriminant analysis. Coverage of applications and current research results.

Prerequisite: ECE(CSC) 514, ST 371, B average in ECE and MA
Typically offered in Spring only

ECE 762 Advanced Digital Communications Systems (3 credit hours)
An advanced graduate-level course in digital communications. Topics include signal design, equalization methods and synchronization techniques for realistic communication channels. Projects concentrate on literature review and computer simulations.

Prerequisite: ECE 515 or equivalent
Typically offered in Fall only

ECE 763 Computer Vision (3 credit hours)
Analysis of images by computers. Specific attention given to analysis of the geometric features of objects in images, such as region size, connectedness and topology. Topics include: segmentation, template matching, motion analysis, boundary detection, region growing, shape representation, 3-D object recognition including graph matching.

Prerequisite: ECE 558 and ECE 514
Typically offered in Spring only

ECE 765 Probabilistic Graphical Models for Signal Processing and Computer Vision (3 credit hours)
Techniques for machine learning using probabilistic graphical models. Emphasis on Bayesian and Markov networks with applications to signal processing and computer vision.

Prerequisites: Programming experience (MATLAB, C++ or other object oriented language such as Python), linear algebra (MA 405 or equivalent), and probability (ECE 514, equivalent or instructor permission)
Typically offered in Fall only

ECE 766 Signal Processing for Communications & Networking (3 credit hours)
This course deals with the signal processing principles underlying recent advances in communications and networking. Topics include: smart-antenna and multi-input multi-output (MIMO) techniques; multiuser communication techniques (multiple access, power control, multiuser detection, and interference managment); signal processing in current and emerging network applications such as cognitive radio and social networks. Knowledge of linear alegbra and stochastic analysis is required.

Prerequisite: Graduate standing
Typically offered in Fall only
This course is offered alternate even years

ECE 773/CSC 773 Advanced Topics in Internet Protocols (3 credit hours)
Cutting-edge concepts and technologies to support internetworking in general and to optimize the performance of the TCP/IP protocol suite in particular. Challenges facing and likely evolution for next generation intenetworking technologies. This course investigates topics that include, but may be not limited to: Internet traffic measurement, characteriztion and modeling, traffic engineering, network-aware applications, quality of service, peer-to-peer systems, content-distribution networks, sensor networks, reliable multicast, and congestion control.

Prerequisite: CSC/ECE 573
Typically offered in Spring only

ECE 774/CSC 774 Advanced Network Security (3 credit hours)
A study of network security policies, models, and mechanisms. Topics include: network security models; review of cryptographic techniques; internet key management protocols; electronic payments protocols and systems; intrusion detection and correlation; broadcast authentication; group key management; security in mobile ad-hoc networks; security in sensor networks.

Prerequisite: CSC/ECE 570, CSC/ECE 574
Typically offered in Spring only

ECE 785 Topics in Advanced Computer Design (3 credit hours)
In depth study of topics in computer design; advantages and disadvantages of various designs and design methodologies; technology shifts, trends, and constraints; hardware/software tradeoffs and co-design methodologies.

Prerequisite: ECE 520, ECE 521
Typically offered in Spring only

ECE 786 Advanced Computer Architecture: Data Parallel Processors (3 credit hours)
In-depth study of processor architectures to exploit data-level parallelism, including general computation on graphics processing units (GPGPU, aka GPU computing architecture) and vector processors; memory subsystems; advantages and disadvantages of various architectures; technology shifts, trends, and constraints.

P: ECE 463/563 and CSC/ECE 506
Typically offered in Spring only

ECE 789/CSC 789 Cellular and Telecommunications Security (3 credit hours)
This course provides an in-depth investigation into security issues in areas including cellular air interfaces, core networking (SS7, IMS), cellular data networking, mobile device architectures, and classic telephone networks. In particular, we will study how these networks provide (or fail to provide) high confidentiality, integrity, availability, authentication, and privacy. A key focus of the course will be how the design philosophy of telephone networks differs from the Internet, complicating traditional security solutions.

Prerequisite: CSC 401 or CSC 405 or CSC 474 or CSC 537 or CSC 570 or CSC 573 or CSC 574 or equivalent
Typically offered in Fall only

ECE 791 Special Topics In Electrical Engineering (3-6 credit hours)
Two-semester sequence to develop new courses and to allow qualified students to explore areas of special interest.

Prerequisite: B average in technical subjects
Typically offered in Fall and Spring

ECE 792 Special Topics In Electrical Engineering (1-6 credit hours)
Two-semester sequence to develop new courses and to allow qualified students to explore areas of special interest.

Prerequisite: B average in technical subjects
Typically offered in Fall and Spring

ECE 801 Seminar in Electrical and Computer Engineering (1-3 credit hours)
Typically offered in Fall and Spring

ECE 804 Seminar in Comm/Sig PR (1-3 credit hours)
Typically offered in Fall and Spring

ECE 833 Individual Topics In Electrical Engineering (1-3 credit hours)
Provision of opportunity for individual students to explore topics of special interest under direction of a member of faculty.

Prerequisite: B average in technical subjects
Typically offered in Fall and Spring

ECE 834 Individual Studies In Electrical Engineering (1-3 credit hours)
The study of advanced topics of special interest to individual students under direction of faculty members.

Prerequisite: Graduate standing
Typically offered in Fall, Spring, and Summer

ECE 875 Projects in Electrical and Computer Engineering (1-3 credit hours)
This course is for long-term projects supervised by ECE faculty for students to explore cutting-edge research in ECE.

Prerequisite: Graduate Standing
Typically offered in Fall, Spring, and Summer

ECE 885 Doctoral Supervised Teaching (1-3 credit hours)
Teaching experience under the mentorship of faculty who assist the student in planning for the teaching assignment, observe and provide feedback to the student during the teaching assignment, and evaluate the student upon completion of the assignment.

Prerequisite: Doctoral student
Typically offered in Fall only

ECE 890 Doctoral Preliminary Examination (1-9 credit hours)
For students who are preparing for and taking writte and/or oral preliminary exams.

Prerequisite: Doctoral student
Typically offered in Fall only

ECE 893 Doctoral Supervised Research (1-9 credit hours)
Instruction in research and research under the mentorship of a member of the Graduate Faculty.

Prerequisite: Doctoral student
Typically offered in Fall only

ECE 895 Doctoral Dissertation Research (1-9 credit hours)
Dissertation research.

Prerequisite: Doctoral student
Typically offered in Fall, Spring, and Summer

ECE 896 Summer Dissertation Research (1 credit hours)
For graduate students whose programs of work specify no formal course work during a summer session and who will be devoting full time to thesis research.

Prerequisite: Doctoral student
Typically offered in Summer only

ECE 899 Doctoral Dissertation Preparation (1-9 credit hours)
For students who have completed all credit hour, full-time enrollment, preliminary examination, and residency requirements for the doctoral degree, and are writing and defending their dissertations.

Prerequisite: Doctoral student
Typically offered in Fall and Spring