ECE - Electrical and Computer Engineering

ECE 201 Circuit Analysis I (3 Credit Hours)
An introduction to the analysis and theory of linear electrical circuits. Topics include: passive component definitions and connection rules; independent and dependent sources, concepts of power & energy; Kirchhoff's laws; development of network reduction techniques; formulation of mesh-current and node-voltage equations; network theorems including Thevenin, Norton, Maximum power transfer, and superposition Theorem, Operational Amplifiers, Energy Storage Elements, and initial conditions. Time Domain Analysis of First Order and Second Order Circuits, Introduction to Phasors. Basics of matrices and linear algebra with Gaussian elimination; matrix applications to linear circuit analyses; MATLAB and Circuit Simulation software (Multisim) with analyses and applications to passive circuits. (offered fall, spring, summer)
Prerequisites: ECE 111 or ENGN 121 or equivalent and a grade of C or better in MATH 212
Pre- or corequisite: PHYS 232N or PHYS 262N

ECE 202 Circuit Analysis II (3 Credit Hours)
Time domain analysis; Sinusoidal steady state analysis; Phasor representation of AC Circuits, Maximum power transfer and Thevenin-Norton theorems for AC circuits; Frequency response of circuits (with R, L, and C components), Laplace Transforms and transfer functions of linear circuits; extension to frequency domain circuit analysis including Bode plots. Active and passive filter design and analysis. (offered fall, spring, summer)
Prerequisites: PHYS 232N or PHYS 262N; MATH 280 or MATH 307 and a grade of C or better in ECE 201

ECE 241 Fundamentals of Computer Engineering (4 Credit Hours)
This course develops the foundation of computer engineering for computer engineers as well as an introductory breadth appropriate for electrical engineers. Class topics include computer information, digital design (combinational and sequential circuits), computer organization, and assembly language. The laboratory includes building digital circuits (focusing on programmable logic), assembly language programming, and system interfacing. The use of a hardware description language is employed in class and the laboratory to specify, simulate and synthesize digital circuits.
Prerequisites: A grade of C or better in CS 150 or ENGN 150 or ENGN 122 and a grade of C or better in MATH 211

ECE 242 Fundamentals of Computer Engineering Lab (1 Credit Hour)
Available for pass/fail grading only. The laboratory includes building digital circuits (focusing on programmable logic), assembly language programming, and system interfacing. The use of a hardware description language is employed in the laboratory to specify, simulate and synthesize digital circuits. This course is only for students who do not have the laboratory component in ECE 241.
Prerequisites: (CS 150 or ENGN 122 or ENGN 150) and MATH 211 with a grade of C or better for both, and written permission of the Chief Departmental Advisor of the Electrical & Computer Engineering Department

ECE 250 Object-Oriented Programming in C++ for Engineers (3 Credit Hours)
Provides coverage of object-oriented programming in C++. Topics include classes, data structures, algorithms, the Standard Template Library (STL), and abstract data types. Assignments will follow a current engineering theme such as autonomous systems to introduce functional decomposition and illustrate course topics.
Prerequisites: ENGN 122
Pre- or corequisite: ECE 241

ECE 287 Fundamental Electric Circuit Laboratory (2 Credit Hours)
Objective of course is to provide students in electrical and computer engineering with a 'hands-on' introduction to selected topics in electrical engineering. Students will use basic circuit analysis skills and programming skills to design, build, and test electrical networks interfacing to an Arduino Uno micro-controller. Labs will also provide an introduction to basic measurement techniques and electrical laboratory equipment (power supplies, oscilloscopes, voltmeters, etc).
Prerequisites: A grade of C or better in both CS 150 or ENGN 150 or ENGN 122 and a grade of C or better in ECE 201
Pre- or corequisite: ENGL 211C or ENGL 221C or ENGL 231C and ECE 202

ECE 300 Math Review for Graduate Engineering Analysis (3 Credit Hours)
Complex algebra, linear algebra and matrix methods, aspects of multivariable calculus, differential equations, Laplace transforms, and aspects of probability. Applications and examples in the field of electrical engineering will be used. The use of Matlab in engineering problem solving will be presented. Course not available to ECE undergraduate majors.
Prerequisites: Departmental approval

ECE 301 Review of Electrical Engineering Analysis (3 Credit Hours)
Electrical engineering problems, including time-domain and frequency-domain circuit analysis, analysis of networks with electronic components. The use of Matlab and Simulink in electrical engineering problem solving will be presented. Course not available to ECE undergraduate majors.
Prerequisites: Departmental approval

ECE 302 Linear System Analysis (3 Credit Hours)
This course covers the fundamental concepts of signal and linear system representation and analysis in continuous time. Topics include: Operations with sinusoids and complex exponentials. Signal properties, operations, and models. System properties, classification, and models. Time-domain system analysis, including impulse response, total system response, stability, and convolution. Fourier analysis of continuous-time signals and signal transmission through linear time-invariant systems. Ideal and practical filters. Advanced matrix operations and linear algebra with applications to signal and system analysis. Characteristic equation of a matrix, eigenvalues and eigenvectors. Performing time and frequency domain analysis using MATLAB. (offered fall, spring).
Prerequisites: MATH 280 or MATH 307 and a grade of C or better in ECE 201 and ECE 202
Pre- or corequisite: ECE 287

ECE 303 Introduction to Electrical Power (3 Credit Hours)
AC steady state power, single-phase and three-phase networks, electric power generation, transformers, transmission lines, electric machinery and the use of power. Energy resources, power plants, renewable energy, electric safety. (offered fall, summer)
Prerequisites: a grade of C or better in ECE 201

ECE 304 Probability, Statistics, and Reliability (3 Credit Hours)
Introduction to probability, probability models, discrete and continuous random variables, statistics, reliability, and stochastic processes. Applications include modeling of physical systems, data analysis, communications, designed engineering experiments, stochastic processes, and hypothesis testing.
Prerequisites: a grade of C or better in MATH 212
Pre- or corequisite: ECE 202

ECE 306 Discrete System Modeling and Simulation (3 Credit Hours)
An introduction to the modeling and simulation of discrete-state, event-driven systems. Models for Discrete Event Systems (DES) are presented including state automata, Petri nets, queuing models, and event graphs. Event management strategies are developed leading to methodologies for simulating DES models. Example engineering simulation applications covered include digital circuits, computer networks, manufacturing, and traffic. Investigation of the steps of a DES simulation study including problem formulation, conceptual model design, simulation model development, input data modeling, output data analysis, verification and validation, and design of simulation experiments.
Prerequisites: A grade of C or better in ECE 241
Pre- or corequisite: ECE 304

ECE 313 Electronic Circuits (4 Credit Hours)
Introduction to junction diodes, bipolar junction transistors (BJTs), MOS field-effect transistors (MOSFETs) and operational amplifiers (op-amps). Design concepts for discrete analog circuits with diodes, BJTs, MOSFETs and op-amps. The lab component introduces design and techniques for implementation of analog circuits.
Prerequisites: A grade of C or better in ENGL 211C or ENGL 221C or ENGL 231C, and a grade of C or better in ECE 201, ECE 202 and ECE 287
Pre- or corequisite: a grade of C or better in ECE 241

ECE 314 Electronics (3 Credit Hours)
Students will be introduced to concepts of signal amplification along with detailed analysis and design of operational amplifier circuits. The main emphasis of the course is to introduce students to the basic operation of PN junctions, and bipolar junction (BJT) and Metal Oxide Semiconductor (MOS) transistors and their application in the design electronic circuits. Detailed large signal and small signal models of these devices will be developed. Analysis and design of basic electronic circuit building blocks with diodes, BJT and MOSFETs will be studied. Both discrete and Integrated Circuits analog design techniques will be covered. The building blocks of an operational amplifier along with differential amplifiers will be covered. Not open to electrical engineering majors or electrical engineering/computer engineering dual majors.
Prerequisites: A grade of C or better in ENGL 211C or ENGL 221C or ENGL 231C, and a grade of C or better in ECE 201, ECE 202 and ECE 287
Pre- or corequisite: a grade of C or better in ECE 241

ECE 320 Continuous System Modeling and Simulation (3 Credit Hours)
An introduction to the fundamentals of modeling and simulating continuous-state, time-driven systems. Topics include state-space model formulation of systems, model representation using block diagrams, stock-flow diagrams and bond graphs, and numerical integration techniques including Taylor series, families of Runge-Kutta and Adams methods. Application domains include electrical systems, signals (including sampling), physical, and biological simulations.
Prerequisites: Junior standing
Pre- or corequisite: ECE 302

ECE 323 Electromagnetics (3 Credit Hours)
This course provides an introduction to the basic concepts of electromagnetics. Topics include math fundamentals for electromagnetic studies, Maxwell's equations, electrostatics, electromagnetic waves, polarization, wave propagation in various media and across interfaces and transmission lines. This fundamental course is to build an electrical engineering/physics foundation for students and enable them to identify, formulate, and solve future engineering problems.
Prerequisites: MATH 285 or MATH 312 and a grade of C or better in ECE 201, ECE 202 and ECE 287

ECE 332 Microelectronic Materials and Processes (3 Credit Hours)
An introduction to fundamental properties of semiconductors and device fabrication processes. The topics include crystal structure, bonding, energy bands, doping, carrier densities, mobility, resistivity, recombination, drift, and diffusion. Basic structure of p-n junctions, BJTs and MOSFETs and their fabrication processes, including solid state diffusion, thermal oxidation of silicon, ion implantation, chemical vapor deposition, thin film deposition, photolithography and etching are reviewed. (offered fall and spring)
Prerequisites: A grade of C or better in ECE 201, ECE 202 and ECE 287

ECE 341 Digital System Design (3 Credit Hours)
Tools and methodologies for top-down design of complex digital systems. Important topics include minimization, mixed logic, algorithmic state machines, microprogrammed controllers, creating and using a gold model, data and control path design and data movement and routing via buses. Design methodologies covered include managing the design process from concept to implementation, verification using a gold model, and introduction to design flow. A hardware description language is used extensively to demonstrate models and methodologies, and is also used in design exercises and projects. (offered fall, spring)
Prerequisites: a grade of C or better in ECE 241

ECE 342 Field Programmable Gate Arrays Design Laboratory (2 Credit Hours)
Introduction to the application of FPGAs for data processing problems. Introduction to interfacing, timing closure, built-in logic analyzers. Emphasis is on the design, simulation, implementation, and testing of digital systems. Design methods incorporate CAD design tools, system on a chip (SoC) tools, implementation with advanced integrated circuit technology and contemporary software tools.
Prerequisites: ECE 341
Pre- or corequisite: ECE 346

ECE 346 Microcontrollers (3 Credit Hours)
This course introduces the principles of microcontrollers and microprocessors. It covers CPU and general architecture based on ARM processor platform. The course will provide students with the necessary knowledge to program, configure, and interface the microcontroller to perform real-world engineering computations using assembly and C programming languages. The course also covers peripheral I/O interfacing such as timers, interrupts, PWM, ADC, and communication interfaces for real-time applications. Students will learn to incorporate microcontrollers into the FPGA boards, and to address safety and security issues. Students will complete the course by designing, building, testing, and troubleshooting a microcontroller consumer application.
Prerequisites: a grade of C or better in ECE 241

ECE 348 Simulation Software Design (3 Credit Hours)
Introduction to data structures, algorithms, programming methodologies, and software architectures in support of computer simulation. Topics include object-oriented programming, data structures (including lists, queues, sets, and trees), algorithms (including searching, sorting, and order of complexity), and advanced topics (reusable code, design patterns, multithreading, and coroutines). Simulation structures developed include event lists, time management, and queuing models. Software models are implemented and tested. Application areas focus on digital circuit and computer networks. The course also analyzes the broader impacts of simulation in a global, economic and societal context.
Prerequisites: ECE 306, CS 381, and a grade of C or better in CS 250 or ECE 250
Pre- or corequisite: ECE 341

ECE 350 Mathematics for Data Analytics Engineering (3 Credit Hours)
Mathematical concepts for data analytics engineering including linear algebra, matrix operations, linear spaces, and advanced differential calculus.
Prerequisites: Grade of C or better in MATH 212
Pre- or corequisite: ECE 304

ECE 355 Introduction to Networks and Data Communications (3 Credit Hours)
This course introduces the basic concepts of computer networks and data communications. Topics include protocol layers, the application layer, the transport layer, the network layer, the data link layer, and the physical layer. Students will learn how to use network packet analyzer tools to do simple network analysis. Emphasis is on gaining an understanding of network engineering as it relates to system operation and maintenance. (offered fall)
Prerequisites: ECE 304 and a grade of C or better in ECE 241

ECE 368 Student Internship/Cooperative Education (1-3 Credit Hours)
Student participation for credit based on the academic relevance of the work experience, criteria, and evaluative procedures as formally determined by the department and Career Development Services prior to the semester in which the work experience is to take place. Upon successful completion, the combination of three consecutive semesters of ECE 368 (one-credit internship) can be considered equivalent to one three-credit Technical Elective course. (offered fall, spring, summer)
Prerequisites: Approval by ECE Chief Department Advisor

ECE 381 Introduction to Discrete-time Signal Processing (3 Credit Hours)
This course covers fundamental digital signal processing (DSP) techniques that form the basis to a wide variety of application areas. Topics include continuous Fourier Transform, discrete-time signals and systems, time domain analysis, solutions of difference equations, Z-transform analysis, Fourier transform (FT), Discrete-time Fourier transform (DTFT), and Discrete Fourier transform (DFT), sampling theorem, and Fourier analysis of linear time-invariant systems. The course also analyzes the broader impacts of DSP in a global, economic, and societal context
Prerequisites: ECE 202

ECE 387 Microelectronics Fabrication Laboratory (3 Credit Hours)
The laboratory course will enable students to fabricate MOSFETs, MOS capacitors, diffused resistors and p-n diodes. Students will be trained to operate the equipment required for wet and dry oxidation, thin film deposition, solid state diffusion, photolithography, and etching. Students will fabricate and analyze the devices by current-voltage characteristic, capacitance-voltage characteristic, film thickness and conductivity measurements. (offered fall and spring).
Prerequisites: ECE 332

ECE 395 Topics in Electrical and Computer Engineering (1-3 Credit Hours)
Study of topics in electrical and computer engineering.
Prerequisites: departmental approval

ECE 396 Topics in Electrical and Computer Engineering (1-3 Credit Hours)
Study of topics in electrical and computer engineering.
Prerequisites: departmental approval

ECE 403/503 Power Electronics (3 Credit Hours)
Power electronics provides the needed interface between an electrical source and an electrical load and facilitates the transfer of power from a source to a load by converting voltages and currents from one form to another. Topics include: alternating voltage rectification, Pulse Width Modulation (PWM), DC converters (Buck, Boost, Buck-Boost, Cuk and SEPIC converters), negative feedback control in power electronics, isolated switching mode power supply, flyback and forward power supply, solid state power switches, AC inverter. (Offered spring)
Prerequisites: ECE 303, ECE 313 and a grade of C or better in ECE 202 and ECE 287

ECE 404/504 Electric Drives (3 Credit Hours)
Electric drives efficiently control the torque, speed and position of electric motors. This course has a multi-disciplinary nature and includes fields such as electric machine theory, power electronics, and control theory. Topics include: switch-mode power electronics, magnetic circuit, DC motor, AC motor, Brushless DC motor, induction motor, speed control of induction motor, vector control of induction motor, stepper-motor. (offered fall)
Prerequisites: ECE 303 and a grade of C or better in ECE 202 and ECE 287

ECE 405/505 Power System Design & Analysis (3 Credit Hours)
This course covers basic power circuit analysis and introductory power system engineering and focuses on the transmission line design, power flow study, short circuit protection, and power distribution in electric power systems, followed by a survey of several applications and case studies. (offered fall)
Prerequisites: ECE 303 and a grade of C or better in ECE 202 and ECE 287, or equivalent knowledge in electric machines and circuits

ECE 406/506 Computer Graphics and Visualization (3 Credit Hours)
The course provides a practical treatment of computer graphics and visualization with emphasis on modeling and simulation applications. It covers digital image and signal processing basics such as sampling and discrete Fourier transform, computer graphics fundamentals, visualization principles, and software architecture for visualization in modeling and simulation. Written communication and information literacy skills are stressed in this course. (Offered fall).
Prerequisites: ECE 348 or CS 361

ECE 407/507 Introduction to Game Development (3 Credit Hours)
An introductory course focused on game development theory and modern practices with emphasis on educational game development. Topics include game architecture, computer graphics theory, user interaction, audio, high level shading language, animation, physics, and artificial intelligence. The developed games can run on a variety of computer, mobile, and gaming platforms. (Offered spring).
Prerequisites: CS 361 or ECE 348

ECE 408/508 Fundamentals of Electric Vehicles (3 Credit Hours)
This course covers the fundamentals of electric vehicles and focuses on the components, power control, energy management, power train dynamics and other related topics in purely electric and hybrid electric vehicle systems, including a survey of several applications and case studies. (Offered spring)
Prerequisites: ECE 303 and a grade of C or better in ECE 202 and ECE 287

ECE 409/509 Introduction to Distributed Simulation (3 Credit Hours)
An introduction to distributed simulation. Topics include motivation for using distributed simulation, distributed simulation architectures, time management issues, and distributed simulation approaches. Current standards for distributed simulation are presented.
Prerequisites: ECE 348

ECE 410/510 Model Engineering (3 Credit Hours)
The goal of this course is to develop understanding of the various modeling paradigms appropriate for capturing system behavior and conducting digital computer simulation of many types of systems. The techniques and concepts discussed typically include UML, concept graphs, Bayesian nets, Markov models, Petri nets, system dynamics, Bond graphs, etc. Students will report on a particular technique and team to implement a chosen system model. (Offered spring).
Prerequisites: ECE 306
Pre- or corequisite: ECE 320

ECE 412/512 Advanced Virtual Reality, Augmented Reality, and Haptics System (3 Credit Hours)
This course is designed to introduce students to the hardware and software required for humans to interact with virtual worlds, both visually and tactilely. Students will be introduced to virtual reality (VR), augmented reality (AR), and haptic devices. A discussion of relative coordinate systems will allow them to virtually position the devices in a virtual world. They will learn to build a haptic device and build an interface using a microcontroller. They will also learn how to interface the devices with a virtual world built in a standard game engine such as Unreal. The course will be project based giving the opportunity to work with VR and AR goggles.
Prerequisites: ECE 250, CS 250 or CS 251 and CS 260 or equivalent

ECE 415/515 Parallel Computing for High-Performance Data Analytics (3 Credit Hours)
Introduction to modeling and analysis of parallel execution performance of emerging simulations on modern high-performance (HPC) and Cloud computing platforms. Hands-on experience with Old Dominion University campus HPC clusters and Cloud-based platforms available globally. Programming models for large-scale and data-analytics applications. Case studies of realistic parallel scientific, engineering, and data-analytics simulations. Course projects may be assigned for students to apply the gained knowledge to analyze execution efficiency of a parallel distributed simulation.
Prerequisites: ENGN 122 or equivalent

ECE 416/516 Cyber Defense Fundamentals (3 Credit Hours)
This course focuses on cybersecurity theory, information protection and assurance, and computer systems and networks security. The objectives are to understand the basic security models and concepts, learn fundamental knowledge and tools for building, analyzing, and attacking modern security systems, and gain hands-on experience in cryptographic algorithms, security fundamental principles, and Internet security protocol and standards. (Offered fall)
Prerequisites: Permission of the instructor
Pre- or corequisite: ECE 355

ECE 418/518 Transportation Simulation and Analytics (3 Credit Hours)
This course is designed to introduce students to i) the fundamental concepts of transportation simulation; ii) traffic simulation models for the planning, design, and operations of modern transportation systems; iii) approaches to develop, calibrate, and validate transportation simulation models; and iv) methods to design and analysis of transportation simulation experiments. This course emphasizes more on the modeling, simulation, and analysis of emerging mobility systems such as connected/autonomous vehicles, electrical vehicles, and micro-mobility. The structured lectures and hands-on work with the simulation tools provide students the ability and practical experience to solve complex, real-world transportation problems with simulation.
Prerequisites: ECE 250, or CS 250, or CS 251 and CS 260, and ECE 306

ECE 419/519 Cyber Physical System Security (3 Credit Hours)
Cyber Physical Systems (CPS) integrate computing, networking, and physical processes. The objectives of this course are to learn the basic concepts, technologies and applications of CPS, understand the fundamental CPS security challenges and national security impact, and gain hands-on experience in CPS infrastructures, critical vulnerabilities, and practical countermeasures. (Offered spring)
Prerequisites: ECE 355 or permission of the instructor

ECE 430/530 Therapy and Function Models for Medical Simulation (3 Credit Hours)
This course introduces students to the main Modeling & Simulation models. (1) Anatomical modeling based on robust medical image segmentation and meshing methodologies. (2) A therapy model to determine the impact of a medical intervention by synthesizing the effect of a therapy on the patient's tissues. (3) A collision model, which interacts with anatomy and therapy models, is used for haptics-driven simulations. This course will also explore physiological simulation and the use of finite elements to model biomechanics.
Prerequisites: ECE 250 or CS 250 or CS 251 and CS 260 or equivalent

ECE 441/541 Advanced Digital Design and Field Programmable Gate Arrays (3 Credit Hours)
Course will present FPGA technologies and methods using CAD design tools for implementation of digital systems using FPGAs. Topics include advanced methods of digital circuit design including specification, synthesis, implementation and prototyping; managing multiple clock domains, static timing analysis, timing closure, system reset design, simulation, and optimization; troubleshooting using embedded logic analyzers and integrated development environments (IDEs). Practical system design examples include general purpose data processing, system on a chip (SOC) prototyping, hardware accelerators, and an introduction to domain specific architectures. (Offered spring)
Prerequisites: ECE 342

ECE 443/543 Computer Architecture (3 Credit Hours)
An introduction to computer architectures. Analysis and design of computer subsystems including central processing units, memories and input/output subsystems. With features based on the ARM architecture, students will learn important concepts, including data paths, computer arithmetic, instruction cycles, pipelining, virtual and cache memories, direct memory access and controller design. (Offered fall).
Prerequisites: ECE 346
Pre- or corequisite: ECE 342

ECE 445/545 Introduction to Computer Vision (3 Credit Hours)
Overview of digital image processing including visual perception, image formation, spatial transformations, image enhancement, color image representation and processing, edge detection, image segmentation, and data processing method for computer vision applications. Hand-on projects will be introduced to better understand computer vision applications. (Offered fall).
Prerequisites: ECE 304 and grade of C or better in either ENGN 122 or ENGN 150 or CS 150 or CS 151 or CS 153

ECE 450/550 Introduction to Machine Learning Engineering (3 Credit Hours)
Machine Learning provides a practical treatment of design, analysis and implementation of algorithms, which learn from examples. Topics include multiple machine learning models: linear regression, logistic regression, neural networks, support vector machines, deep learning, Bayesian learning and unsupervised learning. Students are expected to use popular machine learning tools and algorithms to solve real data engineering problems. (Offered spring)
Prerequisites: ECE 304 and a grade of C or better in either ENGN 122 or ENGN 150 or CS 150 or CS 151 or CS 153

ECE 451/551 Communication Systems (3 Credit Hours)
Fundamentals of communication systems engineering. Modulation methods including continuous waveform modulation (amplitude, angle). Design and analysis of modulation systems and performance in the presence of noise. Communication simulation exercises through computer experiments. (Offered spring)
Prerequisites: ECE 304 and ECE 302

ECE 452/552 Introduction to Wireless Communication Networks (3 Credit Hours)
Introduction to current wireless network technologies and standards. The radio frequency spectrum and radio wave propagation models (pathloss, fading, and multipath). The radio link and link budgets. Modulation, diversity, and multiple access techniques. Wireless network planning and operation. Current and emerging wireless technologies (satellite systems, vehicular/sensor networks). (Offered fall)
Prerequisites: ECE 304 and ECE 302

ECE 453/553 Analysis for Modeling and Simulation (3 Credit Hours)
An introduction to analysis techniques appropriate to the conduct of modeling and simulation studies. Topics include input modeling, random number generation, output analysis, variance reduction techniques, and experimental design. In addition, techniques for verification & validation are introduced. Course concepts are applied to real systems and data.
Prerequisites: ECE 306 and ECE 304

ECE 454/554 Introduction to Bioelectrics (3 Credit Hours)
Covers the electrical properties of cells and tissues as well as the use of electrical and magnetic signals and stimuli in the diagnosis and treatment of disease. Typical topics to be covered include basic cell physiology, endogenous electric fields in the body, electrocardiography, cardiac pacing, defibrillation, electrotherapy, electroporation, electrotherapy in wound healing. In addition, ultrashort electrical pulses for intracellular manipulation and the application of plasmas to biological systems will be covered.
Prerequisites: PHYS 111N or higher; MATH 200 or higher

ECE 455/555 Network Engineering and Design (3 Credit Hours)
This course is an extension of ECE 355 into a semester long project. Emphasis is on gaining an understanding of networking design principles that entails all aspects of the network development life cycle. Topics include campus LAN models and design, VLANs, internetworking principles and design, WAN design, design of hybrid IP networks, differentiated vs. integrated services, traffic flow measurement and management. (offered spring)
Prerequisites: ECE 355 or permission of the instructor

ECE 458/558 Instrumentation (3 Credit Hours)
Computer interfacing using a graphical programming language with applications involving digital-to-analog conversion (DAC), analog-to-digital conversion (ADC), digital input output (DIO), Virtual Instrument System Architecture (VISA) and universal Service Bus (USB). Analysis of sampled data involving use of probability density function, mean and standard derivations, correlations, and the power spectrum. (offered spring, summer)
Prerequisites: ECE 302 or permission of instructor

ECE 461/561 Automatic Control Systems (3 Credit Hours)
This course introduces the fundamental principles and methodologies of feedback control of linear systems. Learn to analyze and design current control systems found in automobiles, aircraft, autonomous vehicles, robots, and many other engineering systems. The course introduces time and frequency domain techniques including root locus, Bode, Nyquist and state space methods together with computer-aided analysis and design. These topics serve as a foundation for further studies in, for example, automation, electrical drives, power electronics, and robotics. (Offered Fall)
Prerequisites: ECE 202

ECE 462/562 Introduction to Medical Image Analysis (MIA) (3 Credit Hours)
Introduction to basic concepts in medical image analysis. Medical image registration, segmentation, feature extraction, and classification are discussed. Basic psychophysics, fundamental ROC analysis and FROC methodologies are covered. (Offered every other spring)
Prerequisites: a grade of C or better in MATH 212

ECE 463/563 Design and Modeling of Autonomous Robotic Systems (3 Credit Hours)
This course focuses on autonomous robotics systems with emphasis on using modeling and simulation (M&S) for system level design and testing. Fundamental concepts associated with autonomous robotic systems are discussed. Course topics include: robotic control, architectures, and sensors as well as more advanced concepts such as error propagation, localization, mapping and autonomy. Design strategies that leverage M&S to accelerate the development and testing of sophisticated autonomous robotic algorithms for individual or teams of robots are covered.
Prerequisites: CS 150 or ENGN 122 or ENGN 150

ECE 464/564 Biomedical Applications of Low Temperature Plasmas (3 Credit Hours)
This course is cross listed between ECE, BME and BIOL. It is designed to be taken by senior undergraduate students and first year graduate students. The course contents are multidisciplinary, combining materials from engineering and the biological sciences. The course covers an introduction to the fundamentals of non-equilibrium plasmas, low temperature plasma sources, and cell biology. This is followed by a detailed discussion of the interaction of low temperature plasma with biological cells, both prokaryotes and eukaryotes. Potential applications in medicine such as wound healing, blood coagulation, sterilization, and the killing of various types of cancer cells will be covered. (Offered fall)
Prerequisites: Senior standing

ECE 468/568 Realtime Interactive Simulation and Visualization (3 Credit Hours)
This course is designed to provide students with advanced knowledge and skills in the field of real-time interactive simulation and visualization using the Unreal game engine with emphasis on applications for engineering and sciences. Topics covered include 3D computer graphics theory fundamentals, software architecture, user interaction, physics engine, artificial intelligence, animation, visual representations of complex data, cross-platform development (desktop, mobile, VR/AR). Applications include robotics simulation, transportation simulation, serious games, medical simulation, virtual laboratories, among others.
Prerequisites: ECE 250 or CS 250 or CS 251 and CS 260 or equivalent

ECE 470/570 Foundations of Cyber Security (3 Credit Hours)
Course provides an overview of theory, tools and practice of cyber security and information assurance through prevention, detection and modeling of cyber attack and recovery from such attacks. Techniques for security modeling, attack modeling, risk analysis and cost-benefit analysis are described to manage the security of cyber systems. Fundamental principles of cyber security and their applications for protecting software and information assets of individual computers and large networked systems are explored. Anatomy of some sample attacks designed to compromise confidentiality, integrity and availability of cyber systems are discussed. (Offered fall).
Prerequisites: A grade of C or better in ENGN 122 or ENGN 150 or CS 150 and junior standing or permission of the instructor

ECE 471/571 Introduction to Solar Cells (3 Credit Hours)
This course is designed to provide the fundamental physics and characteristics of photovoltaic materials and devices. A focus is placed on i) optical interaction, absorption, and design for photovoltaic materials and systems, ii) subsequent energy conversion processes in inorganic/organic semiconductor such as generation, recombination, and charge transport, and iii) photovoltaic testing and measurement techniques to characterize solar cells including contact and series resistance, open circuit voltage, short circuit current density, fill factor, and energy conversion efficiency of photovoltaic devices. (Offered fall)
Prerequisites: ECE 332

ECE 472/572 Plasma Processing at the Nanoscale (3 Credit Hours)
The science and design of partially ionized plasma and plasma processing devices used in applications such as etching and deposition at the nanoscale. Gas phase collisions, transport parameters, DC and RF glow discharges, the plasma sheath, sputtering, etching, and plasma deposition.
Prerequisites: ECE 323

ECE 473/573 Solid State Electronics (3 Credit Hours)
The objective of this course is to understand basic semiconductor devices by understanding semiconductor physics (energy bands, carrier statistics, recombination and carrier drift and diffusion) and to gain an advanced understanding of the physics and fundamental operation of advanced semiconductor devices. Following the initial introductory chapters on semiconductor physics, this course will focus on the theory of p-n junctions, metal-semiconductor Schottky diodes, MOS capacitors, MOS field effect transistors (MOSFET) and bipolar junction transistors (BJTs). (Offered fall)
Prerequisites: ECE 313, ECE 323, ECE 332 and MATH 212

ECE 474/574 Optical Fiber Communication (3 Credit Hours)
This course introduces seniors and first year graduates to the physics and design of optical fiber communication systems. The topics covered are: electromagnetic waves; optical sources including laser diodes; optical amplifiers; modulators; optical fibers; attenuation and dispersion in optical fibers; photodetectors; optical receivers; noise considerations in optical receivers; optical communication systems.
Prerequisites: ECE 323

ECE 475/575 Transportation Data Analytics (3 Credit Hours)
This course presents the basic techniques for transportation data analytics. It will discuss statistical modeling, prominent algorithms, and visualization approaches to analyze both small- and large-scale data sets generated from transportation systems. Practices of using different data for various real-world traffic/transportation applications and decision making will also be discussed.
Prerequisites: STAT 330 or ECE 304

ECE 481W Preparatory ECE Senior Design (3 Credit Hours)
3 credits - The course is the preparatory, proposal development section of the senior capstone design experience for computer engineering and electrical engineering majors. The course will focus on developing a proposal for a group design project. The senior design projects aim at developing engineering design skills of a complete computer/electrical system. Elements of developing a successful proposal are emphasized along with written communication skills, engineering professional development, technical presentation skills, developing an understanding of the societal impact of the project, and developing realistic constraints on the design based on engineering standards. Oral and written communication skills are stressed. This is a writing intensive course. Industry-sponsored multi-disciplinary design projects are an option. (offered Fall, Spring)
Prerequisites: A grade of C or better in ENGL 211C or ENGL 221C or ENGL 231C; ECE 381; (ECE 302; ECE 313) or (ECE 341; ECE 346) or (ECE 302; ECE 320; ECE 341; ECE 346)
Pre- or corequisite: ECE 304; (ECE 303; ECE 323; ECE 332; ECE 451; ECE 461) or (ECE 342 ; ECE 355; ECE 302 or ECE 306 or ECE 350 or ECE 313 or ECE 314; ECE 443) or (ECE 406)

ECE 482 ECE Senior Design (3 Credit Hours)
This is the second semester of the senior capstone design experience for computer engineering, modeling and simulation engineering, and electrical engineering majors. In this course, the students will implement the design proposal developed in ECE 481W. The senior design projects aim at developing engineering design skills of a complete computer/electrical system. Oral and written communication skills are emphasized. Industry-sponsored multi-disciplinary design projects are an option.
Prerequisites: ECE 481W

ECE 483/583 Embedded Systems (3 Credit Hours)
This course covers fundamentals of embedded systems: basic architecture, programming, and design. Topics include processors and hardware for embedded systems, embedded programming and real time operating systems. (Offered fall)
Prerequisites: ECE 346

ECE 484W Computer Engineering Design I (3 Credit Hours)
Emphasis is on the design of a complex digital circuit and microcontroller interfacing. A semester-long project involves the design, simulation and testing of a digital architecture and software GUI. Several moderate scale digital modules are designed, simulated, implemented and tested during the semester. Design methods incorporate CAD design tools, implementation with advanced integrated circuit technology and contemporary software tools. Oral and written communication skills are stressed. This is a writing intensive course.
Prerequisites: A grade of C or better in ENGL 211C or ENGL 221C or ENGL 231C; ECE 302; ECE 341; ECE 346; and ECE 381 OR ECE 320
Pre- or corequisite: ECE 304, ECE 313, and ECE 406 OR ECE 443

ECE 485W Electrical Engineering Design I (3 Credit Hours)
This course is designed to give senior electrical engineering students the opportunity to design and test electronic subsystems to address realistic engineering problems. Lectures focus on providing professional orientation and exploration of the design process. Small group design projects focus on the development of electronic subsystems. Oral and written communication skills are stressed. The students will be in groups of two or three and they are to develop a robot, test its capabilities and modify them to meet a design challenge in the last few weeks of the semester. Topics include programming the ARDUINO UNO, wire- wrap techniques, sensor testing, motor testing, and overall robot functioning. This is a writing intensive course.
Prerequisites: ECE 302, ECE 313 and ECE 381 and a grade of C or better in ENGL 211C or ENGL 221C or ENGL 231C
Pre- or corequisite: ECE 303, ECE 304, ECE 323, and ECE 332

ECE 486 Preparatory ECE Senior Design II (2 Credit Hours)
The course is the preparatory, proposal development section of part two of the senior capstone design experience for electrical and computer engineering majors. The course will focus on developing a proposal for a group design project. The senior design projects aim at developing engineering design skills of a complete computer/electrical system. Elements of developing a successful proposal are emphasized along with written communication skills. Industry-sponsored multi-disciplinary design projects are an option.
Prerequisites: senior standing
Pre- or corequisite: ECE 484W or ECE 485W

ECE 487 ECE Senior Design II (2 Credit Hours)
Part two of the senior capstone design experience for electrical and computer engineering majors. In this course, students will implement the design proposal developed in ECE 486. The senior design projects aim at developing engineering design skills of a complete computer/electrical system. Oral and written communication skills are emphasized. Industry-sponsored multi-disciplinary design projects are an option.
Prerequisites: ECE 486
Pre- or corequisite: ECE 484W or ECE 485W

ECE 488 ECE Senior Design III (3 Credit Hours)
Part three of the senior capstone design experience for electrical and computer engineering majors. Individual and group design projects focus on the development of complete electrical and computer systems. Oral and written communication skills are stressed. Industry-sponsored multi-disciplinary design projects are an option.
Prerequisites: ECE 487

ECE 491 Microelectronics Design Experience (3 Credit Hours)
This is a Virginia Microelectronics Consortium (VMEC) practical hands-on, state-of-the-art summer research internship experience in the laboratory. This is not a regular class, but a summer research internship open only to those undergraduate students who apply for and win a VMEC Summer Research Scholarship. The VMEC internship provides excellent technical knowledge as well as industrial and academic contacts for career development. Students complete a 10-13 week summer project on a microelectronics research project or design activity at an engineering school or in the State-of-the-Art Cleanroom of the industry members of the VMEC, including Micron Technology & British Aerospace Systems (BAE Systems) both in Manassas, VA. Details regarding eligibility and report requirements are available in the department during fall with application deadline of October 30 each fall.
Prerequisites: Sophomore or Junior standing in electrical or computer engineering with GPA above 3.0 and department approval

ECE 495/595 Topics in Electrical and Computer Engineering (1-3 Credit Hours)
Study of topics in electrical and computer engineering.
Prerequisites: departmental approval

ECE 496/596 Topics in Electrical and Computer Engineering (1-3 Credit Hours)
Study of topics in electrical and computer engineering.
Prerequisites: departmental approval

ECE 498 ECE Senior Thesis I (1 Credit Hour)
Part one of a two-semester thesis project involving literature research, development of technical writing skills, and possibly obtaining lab experience using a variety of techniques and equipment. Each student will undertake a research experience under the supervision of a departmental faculty member. A preliminary report of research findings is required at the end of the semester. Upon successful completion, the combination of ECE 498 (1 credit) and ECE 499 (2 credits) can be considered equivalent to one 3-credit ECE Technical Elective Course. (Offered fall, spring, summer)
Prerequisites: Major in Electrical Engineering, Computer Engineering, or Modeling & Simulation Engineering; Cumulative GPA of 3.00 or higher
Pre- or corequisite: ECE 484W or ECE 485W

ECE 499 ECE Senior Thesis II (2 Credit Hours)
Continuation of ECE 498. The research culminates in a thesis that includes a literature review, description of methods, results and conclusions, and an oral presentation. Upon successful completion, the combination of ECE 498 (1 credit) and ECE 499 (2 credits) can be considered equivalent to one 3-credit ECE Technical Elective Course. (Offered fall, spring, summer)
Prerequisites: ECE 498, and a cumulative GPA of 3.00 or better

ECE 503 Power Electronics (3 Credit Hours)
Power electronics provides the needed interface between an electrical source and an electrical load and facilitates the transfer of power from a source to a load by converting voltages and currents from one form to another. Topics include: alternating voltage rectification, Pulse Width Modulation (PWM), DC converters (Buck, Boost, Buck-Boost, Cuk and SEPIC converters), negative feedback control in power electronics, isolated switching mode power supply, flyback and forward power supply, solid state power switches, AC inverter. (Offered spring)
Prerequisites: ECE 303, ECE 313 and a grade of C or better in ECE 202 and ECE 287

ECE 504 Electric Drives (3 Credit Hours)
Electric drives efficiently control the torque, speed and position of electric motors. This course has a multi-disciplinary nature and includes fields such as electric machine theory, power electronics, and control theory. Topics include: switch-mode power electronics, magnetic circuit, DC motor, AC motor, Brushless DC motor, induction motor, speed control of induction motor, vector control of induction motor, stepper-motor. (offered fall)
Prerequisites: ECE 303 and a grade of C or better in ECE 202 and ECE 287

ECE 505 Power System Design & Analysis (3 Credit Hours)
This course covers basic power circuit analysis and introductory power system engineering and focuses on the transmission line design, power flow study, short circuit protection, and power distribution in electric power systems, followed by a survey of several applications and case studies. (offered fall)
Prerequisites: ECE 303 or equivalent knowledge in electric machines and circuits

ECE 506 Computer Graphics and Visualization (3 Credit Hours)
The course provides a practical treatment of computer graphics and visualization with emphasis on modeling and simulation applications. It covers digital image and signal processing basics such as sampling and discrete Fourier transform, computer graphics fundamentals, visualization principles, and software architecture for visualization in modeling and simulation. Written communication and information literacy skills are stressed in this course. (Offered fall).
Prerequisites: ECE 348 or CS 361 or MSIM 603

ECE 507 Introduction to Game Development (3 Credit Hours)
An introductory course focused on game development theory and modern practices with emphasis on educational game development. Topics include game architecture, computer graphics theory, user interaction, audio, high level shading language, animation, physics, and artificial intelligence. The developed games can run on a variety of computer, mobile, and gaming platforms. (Cross listed with MSIM 508). (Offered spring).
Prerequisites: CS 361 or ECE 348

ECE 508 Fundamentals of Electric Vehicles (3 Credit Hours)
This course covers the fundamentals of electric vehicles and focuses on the components, power control, energy management, power train dynamics and other related topics in purely electric and hybrid electric vehicle systems, including a survey of several applications and case studies. (Offered spring)
Prerequisites: ECE 303 and a grade of C or better in ECE 202 and ECE 287

ECE 509 Introduction to Distributed Simulation (3 Credit Hours)
An introduction to distributed simulation. Topics include motivation for using distributed simulation, distributed simulation architectures, time management issues, and distributed simulation approaches. Current standards for distributed simulation are presented.
Prerequisites: ECE 348

ECE 510 Model Engineering (3 Credit Hours)
The goal of this course is to develop understanding of the various modeling paradigms appropriate for capturing system behavior and conducting digital computer simulation of many types of systems. The techniques and concepts discussed typically include UML, concept graphs, Bayesian nets, Markov models, Petri nets, system dynamics, Bond graphs, etc. Students will report on a particular technique and team to implement a chosen system model. (Cross-listed with MSIM 510.)(Offered spring).
Prerequisites: ECE 306 or equivalent
Pre- or corequisite: ECE 320 or equivalent

ECE 512 Advanced Virtual Reality, Augmented Reality, and Haptics System (3 Credit Hours)
This course is designed to introduce students to the hardware and software required for humans to interact with virtual worlds, both visually and tactilely. Students will be introduced to virtual reality (VR), augmented reality (AR), and haptic devices. A discussion of relative coordinate systems will allow them to virtually position the devices in a virtual world. They will learn to build a haptic device and build an interface using a microcontroller. They will also learn how to interface the devices with a virtual world built in a standard game engine such as Unreal. The course will be project based giving the opportunity to work with VR and AR goggles.
Prerequisites: ECE 250 or CS 250 or CS 251 and CS 260 or equivalent

ECE 515 Parallel Computing for High-Performance Data Analytics (3 Credit Hours)
Introduction to modeling and analysis of parallel execution performance of emerging simulations on modern high-performance (HPC) and Cloud computing platforms. Hands-on experience with Old Dominion University campus HPC clusters and Cloud-based platforms available globally. Programming models for large-scale and data-analytics applications. Case studies of realistic parallel scientific, engineering, and data-analytics simulations. Course projects may be assigned for students to apply the gained knowledge to analyze execution efficiency of a parallel distributed simulation.
Prerequisites: ENGN 122 or equivalent

ECE 516 Cyber Defense Fundamentals (3 Credit Hours)
This course focuses on cybersecurity theory, information protection and assurance, and computer systems and networks security. The objectives are to understand the basic security models and concepts, learn fundamental knowledge and tools for building, analyzing, and attacking modern security systems, and gain hands-on experience in cryptographic algorithms, security fundamental principles, and Internet security protocol and standards. (Offered fall)
Prerequisites: Permission of the instructor
Pre- or corequisite: ECE 355

ECE 518 Transportation Simulation and Analytics (3 Credit Hours)
This course is designed to introduce students to i) the fundamental concepts of transportation simulation; ii) traffic simulation models for the planning, design, and operations of modern transportation systems; iii) approaches to develop, calibrate, and validate transportation simulation models; and iv) methods to design and analysis of transportation simulation experiments. This course emphasizes the modeling, simulation, and analysis of emerging mobility systems such as connected/autonomous vehicles, electrical vehicles, and micro-mobility. The structured lectures and hands-on work with the simulation tools provide students the ability and practical experience to solve complex, real-world transportation problems with simulation.
Prerequisites: ECE 250, or CS 250, or CS 251 and CS 260, and ECE 306

ECE 519 Cyber Physical System Security (3 Credit Hours)
Cyber Physical Systems (CPS) integrate computing, networking, and physical processes. The objectives of this course are to learn the basic concepts, technologies and applications of CPS, understand the fundamental CPS security challenges and national security impact, and gain hands-on experience in CPS infrastructures, critical vulnerabilities, and practical countermeasures. (Offered spring)
Prerequisites: ECE 355 or permission of the instructor

ECE 530 Therapy and Function Models for Medical Simulation (3 Credit Hours)
This course introduces students to the main Modeling & Simulation models. (1) Anatomical modeling based on robust medical image segmentation and meshing methodologies. (2) A therapy model to determine the impact of a medical intervention by synthesizing the effect of a therapy on the patient's tissues. (3) A collision model, which interacts with anatomy and therapy models, is used for haptics-driven simulations. This course will also explore physiological simulation and the use of finite elements to model biomechanics.
Prerequisites: ECE 250 or CS 250 or CS 251 and CS 260 or equivalent

ECE 541 Advanced Digital Design and Field Programmable Gate Arrays (3 Credit Hours)
Course will present FPGA technologies and methods using CAD design tools for implementation of digital systems using FPGAs. Topics include advanced methods of digital circuit design including specification, synthesis, implementation and prototyping; managing multiple clock domains, static timing analysis, timing closure, system reset design, simulation, and optimization; troubleshooting using embedded logic analyzers and integrated development environments (IDEs). Practical system design examples include general purpose data processing, system on a chip (SOC) prototyping, hardware accelerators, and an introduction to domain specific architectures. (Offered spring)
Prerequisites: ECE 342

ECE 543 Computer Architecture (3 Credit Hours)
An introduction to computer architectures. Analysis and design of computer subsystems including central processing units, memories and input/output subsystems. With features based on the ARM CPU architecture, students will learn important concepts, including data paths, computer arithmetic, instruction cycles, pipelining, virtual and cache memories, direct memory access and controller design. (Offered fall).
Prerequisites: ECE 346
Pre- or corequisite: ECE 342

ECE 545 Introduction to Computer Vision (3 Credit Hours)
Overview of digital image processing including visual perception, image formation, spatial transformations, image enhancement, color image representation and processing, edge detection, image segmentation, and data processing method for computer vision applications. Hand-on projects will be introduced to better understand computer vision applications. (Offered fall)
Prerequisites: A grade of C or better in either ENGN 122 or ENGN 150 or CS 150 and a grade of C or better in ECE 304

ECE 550 Introduction to Machine Learning Engineering (3 Credit Hours)
Machine Learning provides a practical treatment of design, analysis and implementation of algorithms, which learn from examples. Topics include multiple machine learning models: linear regression, logistic regression, neural networks, support vector machines, deep learning, Bayesian learning and unsupervised learning. Students are expected to use popular machine learning tools and algorithms to solve real data engineering problems. (Offered spring)
Prerequisites: ECE 304 and a grade of C or better in either ENGN 122 or ENGN 150 or CS 150 or CS 151 or CS 153

ECE 551 Communication Systems (3 Credit Hours)
Fundamentals of communication systems engineering. Modulation methods including continuous waveform modulation (amplitude, angle). Design and analysis of modulation systems and the performance in the presence of noise. Communication simulation exercises through computer experiments. (Offered spring)
Prerequisites: ECE 304 and ECE 302

ECE 552 Introduction to Wireless Communication Networks (3 Credit Hours)
Introduction to current wireless network technologies and standards. The radio frequency spectrum and radio wave propagation models (pathloss, fading, and multipath). The radio link and link budgets. Modulation, diversity, and multiple access techniques. Wireless network planning and operation. Current and emerging wireless technologies (satellite systems, vehicular/sensor networks). (Offered fall)
Prerequisites: ECE 304 and ECE 302

ECE 553 Analysis for Modeling and Simulation (3 Credit Hours)
An introduction to analysis techniques appropriate to the conduct of modeling and simulation studies. Topics include input modeling, random number generation, output analysis, variance reduction techniques, and experimental design. In addition, techniques for verification & validation are introduced. Course concepts are applied to real systems and data.
Prerequisites: ECE 306 and ECE 304

ECE 554 Introduction to Bioelectrics (3 Credit Hours)
Covers the electrical properties of cells and tissues as well as the use of electrical and magnetic signals and stimuli in the diagnosis and treatment of disease. Typical topics to be covered include basic cell physiology, endogenous electric fields in the body, electrocardiography, cardiac pacing, defibrillation, electrotherapy, electroporation, electrotherapy in wound healing. In addition, ultrashort electrical pulses for intracellular manipulation and the application of plasmas to biological systems will be covered.
Prerequisites: PHYS 111N or higher; MATH 200 or higher

ECE 555 Network Engineering and Design (3 Credit Hours)
Emphasis is on gaining an understanding of networking design principles that entails all aspects of the network development life cycle. Topics include campus LAN models and design, VLANs, internetworking principles and design, WAN design, design of hybrid IP networks, differentiated vs. integrated services, traffic flow measurement and management. (offered spring)
Prerequisites: ECE 355 or permission of the instructor

ECE 558 Instrumentation (3 Credit Hours)
Computer interfacing using a graphical programming language with applications involving digital-to-analog conversion (DAC), analog-to-digital conversion (ADC), digital input output (DIO), Virtual Instrument System Architecture (VISA) and universal Service Bus (USB). Analysis of sampled data involving use of probability density function, mean and standard derivations, correlations, and the power spectrum. (offered spring, summer)
Prerequisites: ECE 302 or permission of the instructor

ECE 561 Automatic Control Systems (3 Credit Hours)
This course introduces the fundamental principles and methodologies of feedback control of linear systems. Learn to analyze and design current control systems found in automobiles, aircraft, autonomous vehicles, robots, and many other engineering systems. The course introduces time and frequency domain techniques including root locus, Bode, Nyquist and state space methods together with computer-aided analysis and design. These topics serve as a foundation for further studies in, for example, automation, electrical drives, power electronics, and robotics. (Offered fall)
Prerequisites: ECE 202

ECE 562 Introduction to Medical Image Analysis (MIA) (3 Credit Hours)
Introduction to basic concepts in medical image analysis. Medical image registration, segmentation, feature extraction, and classification are discussed. Basic psychophysics, fundamental ROC analysis and FROC methodologies are covered. (Offered every other spring)
Prerequisites: a grade of C or better in MATH 212

ECE 563 Design and Modeling of Autonomous Robotic Systems (3 Credit Hours)
This course focuses on autonomous robotics systems with emphasis on using modeling and simulation (M&S) for system level design and testing. Fundamental concepts associated with autonomous robotic systems are discussed. Course topics include: robotic control, architectures, and sensors as well as more advanced concepts such as error propagation, localization, mapping and autonomy. Design strategies that leverage M&S to accelerate the development and testing of sophisticated autonomous robotic algorithms for individual or teams of robots are covered.
Prerequisites: CS 150 or ENGN 122 or ENGN 150

ECE 564 Biomedical Applications of Low Temperature Plasmas (3 Credit Hours)
This course is cross listed between ECE, BME and BIOL. It is designed to be taken by senior undergraduate students and first year graduate students. The course contents are multidisciplinary, combining materials from engineering and the biological sciences. The course covers an introduction to the fundamentals of non-equilibrium plasmas, low temperature plasma sources, and cell biology. This is followed by a detailed discussion of the interaction of low temperature plasma with biological cells, both prokaryotes and eukaryotes. Potential applications in medicine such as wound healing, blood coagulation, sterilization, and the killing of various types of cancer cells will be covered. (Offered fall)
Prerequisites: Senior standing

ECE 568 Realtime Interactive Simulation and Visualization (3 Credit Hours)
This course is designed to provide students with advanced knowledge and skills in the field of real-time interactive simulation and visualization using the Unreal game engine with emphasis on applications for engineering and sciences. Topics covered include 3D computer graphics theory fundamentals, software architecture, user interaction, physics engine, artificial intelligence, animation, visual representations of complex data, cross-platform development (desktop, mobile, VR/AR). Applications include robotics simulation, transportation simulation, serious games, medical simulation, virtual laboratories, among others.
Prerequisites: ECE 250 or CS 250 or CS 251 and CS 260 or equivalent

ECE 570 Foundations of Cyber Security (3 Credit Hours)
Course provides an overview of theory, tools and practice of cyber security and information assurance through prevention, detection and modeling of cyber attacks and recovery from such attacks. Techniques for security modeling, attack modeling, risk analysis and cost-benefit analysis are described to manage the security of cyber systems. Fundamental principles of cyber security and their applications for protecting software and information assets of individual computers and large networked systems are explored. Anatomy of some sample attacks designed to compromise confidentiality, integrity and availability of cyber systems are discussed. (Offered fall).
Prerequisites: A grade of C or better in ENGN 122 or ENGN 150 or CS 150 and junior standing or permission of the instructor

ECE 571 Introduction to Solar Cells (3 Credit Hours)
This course is designed to provide the fundamental physics and characteristics of photovoltaic materials and devices. A focus is placed on i) optical interaction, absorption, and design for photovoltaic materials and systems, ii) subsequent energy conversion processes in inorganic/organic semiconductor such as generation, recombination, and charge transport, and iii) photovoltaic testing and measurement techniques to characterize solar cells including contact and series resistance, open circuit voltage, short circuit current density, fill factor, and energy conversion efficiency of photovoltaic devices. (Offered fall)
Prerequisites: ECE 332

ECE 572 Plasma Processing at the Nanoscale (3 Credit Hours)
The science and design of partially ionized plasma and plasma processing devices used in applications such as etching and deposition at the nanoscale. Gas phase collisions, transport parameters, DC and RF glow discharges, the plasma sheath, sputtering, etching, and plasma deposition.
Prerequisites: ECE 323

ECE 573 Solid State Electronics (3 Credit Hours)
The objective of this course is to understand basic semiconductor devices by understanding semiconductor physics (energy bands, carrier statistics, recombination and carrier drift and diffusion) and to gain an advanced understanding of the physics and fundamental operation of advanced semiconductor devices. Following the initial introductory chapters on semiconductor physics, this course will focus on the theory of p-n junctions, metal-semiconductor Schottky diodes, MOS capacitors, MOS field effect transistors (MOSFET) and bipolar junction transistors (BJTs). (Offered fall)
Prerequisites: ECE 313, ECE 323, ECE 332 and MATH 212

ECE 574 Optical Fiber Communications (3 Credit Hours)
This course introduces seniors and first year graduates to the physics and design of optical fiber communication systems. The topics covered are: electromagnetic waves; optical sources including laser diodes; optical amplifiers; modulators; optical fibers; attenuation and dispersion in optical fibers; photodetectors; optical receivers; noise considerations in optical receivers; optical communication systems.
Prerequisites: ECE 323

ECE 575 Transportation Data Analytics (3 Credit Hours)
This course presents the basic techniques for transportation data analytics. It will discuss statistical modeling, prominent algorithms, and visualization approaches to analyze both small- and large-scale data sets generated from transportation systems. Practices of using different data for various real-world traffic/transportation applications and decision making will also be discussed.
Prerequisites: STAT 330 or ECE 304

ECE 583 Embedded Systems (3 Credit Hours)
This course covers fundamentals of embedded systems: basic architecture, programming, and design. Topics include processors and hardware for embedded systems, embedded programming and real time operating systems. (Offered fall)
Pre- or corequisite: ECE 346

ECE 595 Topics in Electrical and Computer Engineering (1-3 Credit Hours)
Study of topics in electrical and computer engineering.
Prerequisites: departmental approval

ECE 596 Topics in Electrical and Computer Engineering (1-3 Credit Hours)
Study of topics in electrical and computer engineering.
Prerequisites: departmental approval

ECE 601 Linear Systems (3 Credit Hours)
A comprehensive introduction to the analysis of linear dynamical systems from an input-output and state space point of view. Concepts from linear algebra, numerical linear algebra and linear operator theory are used throughout. Some elements of state feedback design and state estimation are also covered.
Prerequisites: MATH 307

ECE 607 Machine Learning I (3 Credit Hours)
Course provides a practical treatment of design, analysis, implementation and applications of algorithms. Topics include multiple machine learning models: linear models, neural networks, support vector machines, instance-based learning, Bayesian learning, genetic algorithms, ensemble learning, reinforcement learning, unsupervised learning, etc.
Prerequisites: Graduate standing

ECE 611 Numerical Methods in Engineering Analysis (3 Credit Hours)
Course intended to provide graduate students in Electrical and Computer Engineering with a basic knowledge of numerical methods applied to engineering problem-solving process. The course includes the following topics: Introduction to computing (Matlab), Truncation errors and Taylor series, Numerical integration, Solution of non-linear equations, Least-Square regression, Interpolations, Ordinary and partial differential equations, and Finite difference methods. Applications to the area of electrical engineering.
Prerequisites: Graduate standing or advisor's permission (for BS/MS students)

ECE 612 Digital Signal Processing I (3 Credit Hours)
This course covers fundamentals of digital signal processing. Topics include frequency domain analysis of discrete-time signals and linear systems, sampling and reconstruction of signals, the Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT), and digital filter design and implementations. Practical applications and examples will be discussed. Problem solving using MATLAB is required.
Prerequisites: ECE 381 or equivalent

ECE 623 Electromagnetism (3 Credit Hours)
Review of electrostatic and magnetostatic concepts, time varying field, Maxwell's equations, plane wave propagation in various media, transmission lines, optical wave guides, resonant cavities, simple radiation systems, and their engineering applications.
Prerequisites: ECE 323 or equivalent

ECE 642 Computer Networking (3 Credit Hours)
The course is based on the ISO (International Standard Organization) OSI (Open Systems Interconnection) reference model for computer networks. A focus is placed on the analysis of protocols at different layers, network architectures, and networking systems performance analysis. Current topic areas include LANs, MANs, TCP/IP networks, mobile communications, and ATM.
Prerequisites: ECE 455 or ECE 555 or permission of the instructor

ECE 643 Computer Architecture Design (3 Credit Hours)
Digital computer design principles. The course focuses on design of state-of-the-art computing systems. An emphasis is placed on superscalar architectures focusing on the pipelining and out-of-order instruction execution operations.
Prerequisites: ECE 443 or ECE 543

ECE 648 Advanced Digital Design (3 Credit Hours)
This course introduces methods for using high level hardware description language such as VHDL and/or Verilog for the design of digital architecture. Topics include top-down design approaches, virtual prototyping, design abstractions, hardware modeling techniques, algorithmic and register level design, synthesis methods, and application decomposition issues. Final design project is required.
Prerequisites: ECE 341

ECE 651 Statistical Analysis and Simulation (3 Credit Hours)
An introduction to probabilistic and statistical techniques for analysis of signals and systems. This includes a review of probability spaces, random variables, and random processes. Analysis and simulation of systems with random parameters and stochastic inputs are considered.
Prerequisites: MATH 312 and one undergraduate course in probability or statistics or permission of instructor

ECE 652 Wireless Communications Networks (3 Credit Hours)
Fundamental concepts in wireless communication systems and networks: radio waveform propagation modeling (free-space, reflections and multipath, fading, diffraction and Doppler effects); physical and statistical models for wireless channels; modulation schemes for wireless communications and bandwidth considerations; diversity techniques; MIMO systems and space-time coding; multiuser systems and multiple access techniques (TDMA, FDMA. CDMA); spread spectrum and multiuser detection; introduction to wireless networking and wireless standards; current and emerging wireless technologies.
Prerequisites: ECE 451 or ECE 551 or permission of instructor

ECE 667 Cooperative Education (1-3 Credit Hours)
Student participation for credit based on academic relevance of the work experience, criteria, and evaluative procedures as formally determined by the department and the Cooperative Education/Career Development Services program prior to the semester in which the work experience is to take place.

ECE 668 Internship (1-3 Credit Hours)
Academic requirements will be established by the department and will vary with the amount of credit desired. Allows students an opportunity to gain short duration career related experience. Meant to be used for one-time experience. Work may or may not be paid. Project is completed during the term.
Prerequisites: approval by department and Career Development Services

ECE 669 Practicum (1-3 Credit Hours)
Academic requirements will be established by the department and will vary with the amount of credit desired. Allows students an opportunity to gain short duration career related experience. Student is usually already employed - this is an additional project in the organization.
Prerequisites: approval by department and Career Development Services

ECE 695 Topics in Electrical or Computer Engineering (3 Credit Hours)
This course will be offered as needed, depending upon the need to introduce special subjects to target specific areas of master's-level specializations in electrical or computer engineering.

ECE 698 Master's Project (1-3 Credit Hours)
Individual project directed by the student's professor in major area of study.

ECE 699 Thesis (1-9 Credit Hours)
Directed research for the master's thesis.
Prerequisites: departmental approval

ECE 731 Graduate Seminar (1 Credit Hour)
Graduate seminar presentations, given by faculty, students, and invited speakers on a diverse range of technical topics of current interest. A selection of topics will help students prepare for an academic career at a university, liberal arts college, private college, or community college. These selected speakers will also present topics to help students develop essential teaching skills. Student speakers will receive advice and comments from faculties on their communication skills before and after their presentation.
Prerequisites: graduate standing

ECE 742 Computer Communication Networks (3 Credit Hours)
This is an advanced level course in data communications. A focus is placed on the analysis, modeling, and control of computer communication systems. Topics include packet switched networks, circuit switched networks, ATM networks, network programming, network control and performance analysis, network security, and wireless sensor networks.
Prerequisites: ECE 642 or permission of instructor

ECE 754 Advanced Bioelectrics (3 Credit Hours)
Bioelectrics is a new field encompassing both the science and technology of applying electrical stimuli to biological systems. This course covers the pulsed power technology that is required to generate electrical stimuli as well as the biological responses they evoke in cells and tissues. Particular emphasis is placed on the medical applications of bioelectrics, including tumor ablation, gene electrotransfer, wound healing, decontamination with cold plasma, and treatment of cardiac arrhythmias.
Prerequisites: ECE 454 or ECE 554 or BIOE 454 or BIOE 554

ECE 755 Biomembranes and Ion Channels (3 Credit Hours)
This course will give an overview of the structure and dynamics of biomembranes, the ion channels that are embedded in them, and the electrical properties of biomembranes. Topics include molecular dynamics modeling of biomembranes, membrane damage and repair, ion channel dynamics and their experimental assessment using patch clamping, and excitability in neurons and cardiomyocytes.
Prerequisites: ECE 454 or ECE 554 or BIOL 523

ECE 762 Digital Control Systems (3 Credit Hours)
Mathematical representation, analysis, and design of discrete-time and sampled-data control systems. Topics include transfer function and state space representations, stability, the root locus method, frequency response methods, and state feedback.
Prerequisites: ECE 381, ECE 461 or ECE 561, and ECE 601 or permission of instructor

ECE 763 Multivariable Control Systems (3 Credit Hours)
A comprehensive introduction to techniques applicable in control of complex systems with multiple inputs and outputs. Both the frequency domain and state variable approaches are utilized. Special topics include robust and optimal control.
Prerequisites: ECE 461 or ECE 561 and ECE 601 or permission of instructor

ECE 766 Nonlinear Control Systems (3 Credit Hours)
An introduction to mathematical representation, analysis, and design of nonlinear control systems. Topics include phase-plane analysis, Lyapunov stability theory for autonomous and nonautonomous systems, formal power series methods and differential geometric design techniques.
Prerequisites: ECE 461 or ECE 561 and ECE 601 or permission of instructor

ECE 772 Fundamentals of Solar Cells (3 Credit Hours)
The course provides an overview of the fundamentals of solar cell technologies, design, and operation. The course is designed for graduate students in Engineering and Science interested in the field of alternative energy. The course objectives are to make sure each student: understands the various forms of alternative energies, understands solar cell design, understands solar cell operation, and acquires knowledge of the various solar cells technologies. The topics to be covered include: Alternative energies; Worldwide status of Photovoltaics; Solar irradiance; Review of semiconductor properties; Generation, recombination; Basic equations of device physics; p-n junction diodes; Ideal solar cells; Efficiency limits; Efficiency losses and measurements; Module fabrication; c-Si technology; classical; Photovoltaic systems; Design of stand-alone system; Residential PV systems.
Prerequisites: Graduate standing in Engineering and Science

ECE 773 Introduction to Nanotechnologies (3 Credit Hours)
This course will introduce the rapidly emerging field of nanotechnology with special focus on underlying principles and applications relevant to the nanoscale dimensions. Specifically, this course will cover (1) the basic principles related to synthesis and fabrication of nanomaterials and nanostructures, (2) zero-, one-, two- and three-dimensional nanostructures, (3) characterization and properties of nanomaterials, and (4) application of nanoscale devices.
Prerequisites: graduate standing in Engineering and Science

ECE 774 Semiconductor Characterization (3 Credit Hours)
Introduction of basic methods for semiconductor material and device characterization. Topics include resistivity, carrier doping concentration, contact resistance, Schottky barrier height, series resistance, channel length, threshold voltage, mobility, oxide and interface trapped charge, deep level impurities, carrier lifetime, and optical, chemical and physical characterization.
Prerequisites: ECE 473 or ECE 573 or equivalent

ECE 775 Non-thermal Plasma Engineering (3 Credit Hours)
This course covers the fundamental principals governing low temperature plasma discharges and their applications. First the fundamental properties of plasmas are introduced. These include the kinetic theory of gases, collisional processes, and plasma sheaths. Then in-depth coverage of the physical mechanisms underlying the operation of non-equilibrium plasma discharges is presented, including important characteristics such as their ignition, evolution, and eventual quenching. Finally, practical applications of non-thermal plasmas, including applications in biology and medicine, are presented.
Prerequisites: graduate standing

ECE 777 Semiconductor Process Technology (3 Credit Hours)
Theory, design and fabrication of modern integrated circuits that consist of nano scale devices and materials. Topics include crystal growth and wafer preparation process including epitaxy, thin film deposition, oxidation, diffusion, ion implantation, lithography, dry etching, VLSI process integration, diagnostic assembly and packaging, yield and reliability.
Prerequisites: ECE 473 or ECE 573

ECE 780 Machine Learning II (3 Credit Hours)
Advanced topics in machine learning and pattern recognition systems. Data reduction techniques including principle component analysis, independent component analysis and manifold learning. Introduction to sparse coding and deep learning for data representation and feature extraction.
Prerequisites: ECE 607 or equivalent

ECE 782 Digital Signal Processing II (3 Credit Hours)
Review of fundamental concepts in digital signal processing: time and frequency domain analysis of discrete time signals and systems, Fourier transforms (DFT/FFT), digital filters, analysis, design, and implementation. Recursive and non-recursive digital filter analysis and design. Multirate signal processing. Random signal modeling and parameter estimation. Signal estimation, orthogonality and normal equations, optimal linear filters. Spectrum estimation. Problem solving using MATLAB is required.
Prerequisites: ECE 612 or equivalent

ECE 783 Digital Image Processing (3 Credit Hours)
Principles and techniques of two-dimensional processing of images. Concepts of scale and spatial frequency. Image filtering in spatial and transform domains. Applications include image enhancement and restoration, image compressing, and image segmentation for computer vision.
Prerequisites: ECE 381 or ECE 612 or ECE 782 or ECE 882

ECE 784 Computer Vision (3 Credit Hours)
Principles and applications of computer vision, advanced image processing techniques as applied to computer vision problems, shape analysis and object recognition.
Prerequisites: graduate standing

ECE 787 Digital Communications (3 Credit Hours)
Fundamental concepts of digital communication and information transmission: information sources and source coding; orthonormal expansions of signals, basis functions, and signal space concepts; digital modulation techniques including PAM, QAM, PSK and FSK; matched filters, demodulation and optimal detection of symbols and sequences; bandwidth; mathematical modeling of communication channels; channel capacity.
Prerequisites: ECE 451/ECE 551 or equivalent or permission of the instructor

ECE 795 Topics in Electrical and Computer Engineering (3 Credit Hours)
Topics in Electrical and Computer Engineering
Prerequisites: departmental approval

ECE 796 Topics in Electrical and Computer Engineering (3 Credit Hours)
Study of selected topics in Electrical and Computer Engineering.
Prerequisites: departmental approval

ECE 797 Independent Study (1-3 Credit Hours)
This course allows students to develop specialized expertise by independent study (supervised by a faculty member).
Prerequisites: departmental approval

ECE 831 Graduate Seminar (1 Credit Hour)
Graduate seminar presentations, given by faculty, students, and invited speakers on a diverse range of technical topics of current interest. A selection of topics will help students prepare for an academic career at a university, liberal arts college, private college, or community college. These selected speakers will also present topics to help students develop essential teaching skills. Student speakers will receive advice and comments from faculties on their communication skills before and after their presentation.

ECE 842 Computer Communication Networks (3 Credit Hours)
This is an advanced level course in data communications. A focus is placed on the analysis, modeling, and control of computer communication systems. Topics include packet switched networks, circuit switched networks, ATM networks, network programming, network control and performance analysis, network security, and wireless sensor networks.
Prerequisites: ECE 642 or permission of instructor

ECE 854 Advanced Bioelectrics (3 Credit Hours)
Bioelectrics is a new field encompassing both the science and technology of applying electrical stimuli to biological systems. This course covers the pulsed power technology that is required to generate electrical stimuli as well as the biological responses they evoke in cells and tissues. Particular emphasis is placed on the medical applications of bioelectrics, including tumor ablation, gene electrotransfer, wound healing, decontamination with cold plasma, and treatment of cardiac arrhythmias.
Prerequisites: ECE 454 or ECE 554 or BIOE 454 and BIOE 554

ECE 855 Biomembranes and Ion Channels (3 Credit Hours)
This course will give an overview of the structure and dynamics of biomembranes, the ion channels that are embedded in them, and the electrical properties of biomembranes. Topics include molecular dynamics modeling of biomembranes, membrane damage and repair, ion channel dynamics and their experimental assessment using patch clamping, and excitability in neurons and cardiomyocytes.
Prerequisites: ECE 454 or ECE 554 or BIOL 523

ECE 861 Advanced Probabilistic Methods for Electrical and Computer Engineering (3 Credit Hours)
This course focuses on three common problems in electrical and computer engineering that are best addressed using probabilistic methods: detecting the absence or presence of a signal in noise, estimating unknown parameters using noisy measurements, and allocating limited resources when demand is uncertain. Applications include computer networks, communication systems, control systems, power distribution networks, and biomedical systems. In each case, specific algorithms are presented for solving these problems along with the supporting analysis for predicting their performance.
Prerequisites: ECE 651

ECE 862 Digital Control Systems (3 Credit Hours)
Mathematical representation, analysis, and design of discrete-time and sampled-data control systems. Topics include transfer function and state space representations, stability, the root locus method, frequency response methods, and state feedback.
Prerequisites: ECE 381, ECE 461 or ECE 561, and ECE 601 or permission of instructor

ECE 863 Multivariable Control Systems (3 Credit Hours)
A comprehensive introduction to techniques applicable in control of complex systems with multiple inputs and outputs. Both the frequency domain and state variable approaches are utilized. Special topics include robust and optimal control.
Prerequisites: ECE 461 or ECE 561 and ECE 601 or permission of the instructor

ECE 866 Nonlinear Control Systems (3 Credit Hours)
An introduction to mathematical representation, analysis, and design of nonlinear control systems. Topics include phase-plane analysis, Lyapunov stability theory for autonomous and nonautonomous systems, formal power series methods and differential geometric design techniques.
Prerequisites: ECE 461 or ECE 561 and ECE 601 or permission of instructor

ECE 872 Fundamentals of Solar Cells (3 Credit Hours)
The course provides an overview of the fundamentals of solar cell technologies, design, and operation. The course is designed for graduate students in Engineering and Science interested in the field of alternative energy. The course objectives are to make sure each student: understands the various forms of alternative energies, understands solar cell design, understands solar cell operation, and acquires knowledge of the various solar cells technologies. The topics to be covered include: Alternative energies; Worldwide status of Photovoltaics; Solar irradiance; Review of semiconductor properties; Generation, recombination; Basic equations of device physics; p-n junction diodes; Ideal solar cells; Efficiency limits; Efficiency losses and measurements; Module fabrication; c-Si technology; classical; Photovoltaic systems; Design of stand-alone system; Residential PV systems.
Prerequisites: Graduate standing in Engineering and Science

ECE 873 Introduction to Nanotechnologies (3 Credit Hours)
This course will introduce the rapidly emerging field of nanotechnology with special focus on underlying principles and applications relevant to the nanoscale dimensions. Specifically, this course will cover (1) the basic principles related to synthesis and fabrication of nanomaterials and nanostructures, (2) zero-, one-, two- and three-dimensional nanostructures, (3) characterization and properties of nanomaterials, and (4) application of nanoscale devices.
Prerequisites: graduate standing in Engineering and Science

ECE 874 Semiconductor Characterization (3 Credit Hours)
Introduction of basic methods for semiconductor material and device characterization. Topics include resistivity, carrier doping concentration, contact resistance, Schottky barrier height, series resistance, channel length, threshold voltage, mobility, oxide and interface trapped charge, deep level impurities, carrier lifetime, and optical, chemical and physical characterization.
Prerequisites: ECE 473 or ECE 573 or equivalent

ECE 875 Non-thermal Plasma Engineering (3 Credit Hours)
This course covers the fundamental principals governing low temperature plasma discharges and their applications. First the fundamental properties of plasmas are introduced. These include the kinetic theory of gases, collisional processes, and plasma sheaths. Then in-depth coverage of the physical mechanisms underlying the operation of non-equilibrium plasma discharges is presented, including important characteristics such as their ignition, evolution, and eventual quenching. Finally, practical applications of non-thermal plasmas, including applications in biology and medicine, are presented.
Prerequisites: graduate standing

ECE 877 Semiconductor Process Technology (3 Credit Hours)
Theory, design and fabrication of modern integrated circuits that consist of nano scale devices and materials. Topics include crystal growth and wafer preparation process including epitaxy, thin film deposition, oxidation, diffusion, ion implantation, lithography, dry etching, VLSI process integration, diagnostic assembly and packaging, yield and reliability.
Prerequisites: ECE 473 or ECE 573

ECE 880 Machine Learning II (3 Credit Hours)
Advanced topics in machine learning and pattern recognition systems. Data reduction techniques including principle component analysis, independent component analysis and manifold learning. Introduction to sparse coding and deep learning for data representation and feature extraction.
Prerequisites: ECE 607 or equivalent

ECE 882 Digital Signal Processing II (3 Credit Hours)
Review of fundamental concepts in digital signal processing: time and frequency domain analysis of discrete time signals and systems, Fourier transforms (DFT/FFT), digital filters, analysis, design, and implementation. Recursive and non-recursive digital filter analysis and design. Multirate signal processing. Random signal modeling and parameter estimation. Signal estimation, orthogonality and normal equations, optimal linear filters. Spectrum estimation. Problem solving using MATLAB is required.
Prerequisites: ECE 612 or equivalent

ECE 883 Digital Image Processing (3 Credit Hours)
Principles and techniques of two-dimensional processing of images. Concepts of scale and spatial frequency. Image filtering in spatial and transform domains. Applications include image enhancement and restoration, image compressing, and image segmentation for computer vision.
Prerequisites: ECE 381 or ECE 612 or ECE 782 or ECE 882

ECE 884 Computer Vision (3 Credit Hours)
Principles and applications of computer vision, advanced image processing techniques as applied to computer vision problems, shape analysis and object recognition.
Prerequisites: Graduate standing

ECE 887 Digital Communications (3 Credit Hours)
Fundamental concepts of digital communication and information transmission: information sources and source coding; orthonormal expansions of signals, basis functions, and signal space concepts; digital modulation techniques including PAM, QAM, PSK and FSK; matched filters, demodulation and optimal detection of symbols and sequences; bandwidth; mathematical modeling of communication channels; channel capacity.
Prerequisites: ECE 451/ECE 551 or equivalent or permission of the instructor

ECE 892 Doctor of Engineering Project (1-12 Credit Hours)
Directed individual study applying advanced level technical knowledge to identify, formulate, and solve a complex, novel problem in electrical and computer engineering.

ECE 895 Topics in Electrical and Computer Engineering (3 Credit Hours)
Topics in Electrical and Computer Engineering.
Prerequisites: departmental approval

ECE 896 Topics in Electrical and Computer Engineering (3 Credit Hours)
Topics in Electrical and Computer Engineering

ECE 897 Independent Study (1-3 Credit Hours)
This course allows students to develop specialized expertise by independent study (supervised by a faculty member)
Prerequisites: departmental approval

ECE 899 Dissertation Research (1-9 Credit Hours)
Directed research for the doctoral dissertation.
Prerequisites: departmental approval

ECE 998 Master's Graduate Credit (1 Credit Hour)
This course is a pass/fail course for master's students in their final semester. It may be taken to fulfill the registration requirement necessary for graduation. All master's students are required to be registered for at least one graduate credit hour in the semester of their graduation.

ECE 999 Doctoral Graduate Credit (1 Credit Hour)
This course is a pass/fail course doctoral students may take to maintain active status after successfully passing the candidacy examination. All doctoral students are required to be registered for at least one graduate credit hour every semester until their graduation.