Electrical Engineering (ECE)

Course information contained within the Bulletin is accurate at the time of publication in August 2023 but is subject to change. For the most up-to-date course information, please refer to the Course Catalog.

ECE 0822. Investing for the Future. 4 Credit Hours.
This class will teach you about seemingly complicated financial topics in a very comprehensible manner that will help you make informed financial decisions to ensure a secure financial future. We begin with identification of common financial problems among the "young, fabulous and broke" and how to avoid them. After thinking about life and financial priorities, we address why thinking about retirement now must be at the top of your list. We examine how to compute your retirement needs and how to get there, primarily with a focus on investing in common stock. You will learn how to think smart about big ticket purchases such as cars, housing, and graduate/professional education. Finally we will make sure you understand how to create a safety net to protect your future. NOTE: This course fulfills the Quantitative Literacy (GQ) requirement for students under GenEd and a Quantitative Reasoning (QA or QB) requirement for students under Core. Students cannot receive credit for this course if they have successfully completed FIN 0822, FIN 0922 or RMI 0822.

Course Attributes: GQ

Repeatability: This course may not be repeated for additional credits.

ECE 0832. Digital World and Everyday Life. 3 Credit Hours.
Every career is being shaped by digital technology. Buzzwords like Cryptocurrency, Artificial Intelligence, Smart Grid, Big Data, The Cloud, Internet of Things, 5G, and Augmented Reality appear in news articles every day. How do all these technologies fit into your daily life and your future career? This class will help you to understand the current state of digital technology and give you the foundation to understand future technological innovations including understanding the fourth industrial revolution, a.k.a. "Industry 4.0". You will gain foundational knowledge such as how computers work, how they communicate with each other, and how people program computers. You will apply this foundational knowledge to more advanced topics such as the topics at the start of the course description. Lastly, the course will describe the ethical considerations of these changes and what role policy should play. NOTE: This course fulfills a Science & Technology (GS) requirement for students under GenEd and a Science & Technology Second Level (SB) requirement for students under Core.

Department Restrictions: May not be enrolled in one of the following Departments: CST:Computer & Info Sci, Engineering:Elec Engineering.
Field of Study Restrictions: May not be enrolled in one of the following Majors: Computer & Information Science, Electrical Engineering.

Course Attributes: GS

Repeatability: This course may not be repeated for additional credits.

ECE 1012. Introduction to Electrical Engineering. 2 to 3 Credit Hours.
This course introduces basic concepts in Electrical and Computer Engineering, and demonstrates them in the context of real applications. Course topics include basics of DC and AC circuits, transistor, diode and operational amplifier circuits, digital logic gates and power supply operation. Students assemble and test a robot car or mouse as part of the class project.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (any MATH course numbered 1022 to 4999, 'Y' in MC6, 'Y' in MC6A, 'Y' in MATW, 'Y' in MC6T, or 'Y' in METW)

ECE 1014. Evolution of Modern Electronic Systems. 3 Credit Hours.
Introduction to modern electronic systems such as telephone networks, television, radio, radar, and computers. Key discoveries such as the vacuum tube, transistor, and laser are covered. The fundamental operating principles are presented in a non-mathematical and historic context. The evolution of these technologies is presented in terms of the need for communication systems and their impact on society. NOTE: This course can be used to satisfy the university Core Science & Technology Second Level (SB) requirement.

Course Attributes: SB

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (any course with attribute "SA" or any course with attribute "GS")

ECE 1022. Technology and You. 3 Credit Hours.
The practitioners of science are scientists. However, we never refer to the practitioners of technology as technologists; rather, they are always referred to as engineers. Therefore understanding the process of engineering is to understand the process of technological development. The engineer of today is either making an old technology better or developing a new technology. As will be illustrated in the readings, engineering is a human endeavor that has existed since the dawn of human kind. To understand engineering and its roots is to understand and appreciate one of humanity's greatest assets. NOTE: This course can be used to satisfy the university Core Science & Technology Second Level (SB) requirement.

Course Attributes: SB

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (any course with attribute "SA" or any course with attribute "GS")

ECE 1111. Engineering Computation I. 4 Credit Hours.
This course will cover the essentials of computer program design, development, testing, and debugging for engineers. In addition to fundamentals such as loops, branching, and subroutines, the course will discuss memory management, pointers, file and data I/O, compilers and linkers, objects, data structures, algorithms, and variable scope. Students will become familiar with scientific and technical computing in the context of solving engineering design challenges. The course will be programming intensive, and students will be expected to code both in and out of class.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (MATH 1041, MATH 1941, MATH 1038, 'Y' in MATW, or 'Y' in METW), (MATH 1042, MATH 1942, 'Y' in MATW, or 'Y' in METW), ENGR 1102, PHYS 1062, ENGR 2011 (may be taken concurrently), and ENGR 2013 (may be taken concurrently)

ECE 1112. Electrical Applications. 2 Credit Hours.
This course introduces basic concepts in Electrical and Computer Engineering, and demonstrates them in the context of real applications. Course topics include basics of DC and AC circuits, transistor, diode and operational amplifier circuits, digital logic gates and power supply operation.

Co-requisites: ECE 1113.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (any MATH course numbered 1022 to 4999, 'Y' in MC6, 'Y' in MC6A, 'Y' in MATW, 'Y' in MC6T, or 'Y' in METW)

ECE 1113. Electrical Applications Laboratory. 1 Credit Hour.
Laboratory for ECE 1112 (0007): Electrical Applications. This is a hands-on lab based on the material covered in ECE 1112.

Co-requisites: ECE 1112.

Repeatability: This course may not be repeated for additional credits.

ECE 2105. Introduction to Cyber Physical Security. 3 Credit Hours.
This is an introductory course to build foundational knowledge in Cyber Physical Security. While Cyber Security (CS) is to ensure security when we use globally interconnected digital network, Cyber Physical Security (CPS) is to ensure the security of critical, real-time, automated and distributed cyber physical infrastructures and facilities that we depend our livelihood on such as water, power (electrical), energy (oil, nuclear), communication, transportation, manufacturing, the emerging world of Internet-of-Things (IoT). This course starts with high level knowledge areas in CS foundations and principles. The course then expands to knowledge areas in Industrial Control System (ICS), embedded systems, mobile technology, wireless sensor networks, and hardware and firmware security, highlighting various architectures, devices, network, operations, processes, and their vulnerability and potential resilient solutions. Case studies such as an actual attack on power grids are used to analyze the incident and its responses. In some cases, tools are used to demonstrate the CPS applications.

Degree Restrictions: Must be enrolled in one of the following Degrees: Bachelor Sci in Engineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in ENGR 1101.

ECE 2112. Electrical Devices & Systems I. 3 Credit Hours.
The purpose of this course is to teach non-Electrical Engineering major students the basics of Electrical circuits and systems, such as: voltage and current, electrical elements (resistors, inductors, capacitors), Kirchoff current and voltage Laws, parallel and series connections, time domain vs. frequency domain analysis, AC power, three phase systems, electrical machines, operational amplifiers, semiconductor diodes and transistors.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (PHYS 1062 or PHYS 1022) and (MATH 1042 (may be taken concurrently), MATH 1942 (may be taken concurrently), MATH 1031 (may be taken concurrently), 'Y' in MATW, or 'Y' in METW)

ECE 2113. Electrical Devices & Systems I Lab. 1 Credit Hour.
The purpose of this course is to teach non-Electrical Engineering major students the basics of Electrical circuits and systems in a laboratory environment and to reinforce the theoretical concepts of ECE 2112 by using experimentation.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in ECE 2112 (may be taken concurrently)

ECE 2122. Electrical Devices and Systems II. 4 Credit Hours.
Students will study circuit analysis using frequency domain techniques, Laplace Transforms, Operational amplifiers, elements of semiconductor devices, electronic circuits, and logic circuits. Students will work on practical applications relating primarily to the mechanical engineering discipline. The laboratory portion of this course allows students to undertake practical applications of the principles discussed in the lecture. NOTE: This course is for Mechanical Engineering majors only.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in ECE 2112 (D- or higher) and (MATH 1042, MATH 1942, 'Y' in MATW, or 'Y' in METW)

ECE 2142. Engineering Principles for Building Science. 4 Credit Hours.
The engineering design approach centers around principles that apply across disciplines, especially those focused on those studying structures. Every architectural student should have an instinctive understanding of fundamental and traditional concepts in the engineering approach to solving problems in making creative design decisions within physical constraints and requirements. Students will learn properties of structures and materials in context of building science and apply their knowledge to solve open ended problems with focus on intelligently choosing methods rather than arriving at exact solutions. Students will become familiar with emerging technologies while relating them to fundamental concepts. The course is design project based with topics including: Vectors, Physical Modeling of Forces, Free Body Diagrams, Structure Analysis, Perspective, Camera/Projector Optics, Introduction to Sensors, Networks and Smart Buildings.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (MATH 1031, any MATH course numbered 1032 to 4999, 'Y' in MATW, or 'Y' in METW)

ECE 2312. Electrical Engineering Science I. 3 Credit Hours.
Electric circuit fundamentals including DC and transient circuit analysis are covered in the course. Topics include independent and dependent sources, circuit elements such as resistors, inductors, capacitors and operational amplifiers, linearity, source transformation, Thevenin and Norton equivalent circuits, as well as the analysis and design of first and second order circuits.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in (MATH 1042 (may be taken concurrently), MATH 1942 (may be taken concurrently), MATH 1951 (C or higher; may be taken concurrently), any MATH course numbered 2043 to 3080 (may be taken concurrently), 'Y' in MA07, 'Y' in MATW, or 'Y' in METW), PHYS 1062 (may be taken concurrently), and ECE 2313 (may be taken concurrently)

ECE 2313. Electrical Engineering Science I Lab. 1 Credit Hour.
This laboratory is concerned with the analysis and design of first and second order circuits with direct current (DC) power sources. This laboratory complements ECE 2312: Electrical Engineering Science I. Topics include independent and dependent sources, circuit elements such as resistors, inductors, capacitors, and operational amplifiers. We also investigate the concept of linearity and source transformation, Thevenin equivalent circuits, and Norton Equivalent circuits.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in ECE 2312 (may be taken concurrently)

ECE 2322. Electrical Engineering Science II. 3 Credit Hours.
This course is concerned with the analysis of alternate current (AC) circuits. Sinusoidal steady-state analysis, AC power analysis, magnetically coupled circuits, and frequency responses are covered. Laplace transforms are introduced and are used to solve first, second and higher order differential equations. The use of Laplace transforms for circuit analysis is studied and applied.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in ECE 2312, ECE 2323 (may be taken concurrently), and (MATH 1042 (C or higher; may be taken concurrently), 'Y' in MATW, 'Y' in CRMA09, or 'Y' in METW)

ECE 2323. Electrical Engineering Science II Lab. 1 Credit Hour.
This course provides hands-on experience of the principles discussed in ECE 2322. Specifically students will gain practical experience on the use of various electrical equipment and their applications for measuring alternating current quantities.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in ECE 2322 (may be taken concurrently)

ECE 2332. Principles of Electric Circuits. 4 Credit Hours.
Electric circuit fundamentals including DC and AC circuit analysis are covered in the course. Topics include circuit elements such as resistors, inductors, capacitors, voltage and current sources, and operational amplifiers; methods of circuit analysis, such as superposition theorem, Thevenin and Norton equivalent circuits, as well as the analysis of first and second order circuits. Sinusoidal steady-state analysis, AC power analysis, magnetically coupled circuits, and frequency responses are covered. Laplace transforms are introduced and are used to solve first, second and higher order differential equations.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (MATH 1041, MATH 1941, MATH 1038, 'Y' in MATW, or 'Y' in METW) and (MATH 1042 (may be taken concurrently), MATH 1942 (may be taken concurrently), 'Y' in MATW, or 'Y' in METW)

ECE 2333. Principles of Electric Circuits Lab. 1 Credit Hour.
This is a hands-on laboratory course for electric circuit fundamentals including DC and AC circuits. Experiments for this laboratory course will be based on the course material covered in ECE 2332. Topics include series and parallel circuits in DC and AC, frequency response, transient response, and AC sinusoidal response.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in ECE 2332.

ECE 2342. Circuits and Electronics I. 5 Credit Hours.
This course is the first in a three-course sequence intended to provide students with foundational knowledge and skills in electrical and computer engineering. In this first course, students will analyze and design DC and AC circuits with linear components such as resistors, inductors, and capacitors. Operational amplifiers will also be studied. Analysis techniques include Kirchoff's voltage and current laws, phasors methods, complex impedance, AC power, Thevenin and Norton equivalent models. Students will explore course concepts in integrated laboratory experiments which include design projects.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (MATH 1041, MATH 1941, MATH 1038, 'Y' in MATW, or 'Y' in METW), (MATH 1042, MATH 1942, 'Y' in MATW, or 'Y' in METW), ENGR 1102, PHYS 1062, ENGR 2011 (may be taken concurrently), and ENGR 2013 (may be taken concurrently)

ECE 2352. Circuits and Electronics II. 5 Credit Hours.
This course is the second in a three-course sequence intended to provide students with foundational knowledge and skills in electrical and computer engineering. In this second course, students will build on concepts learned in Circuits and Electronics I. They will analyze and design DC and AC circuits containing non-linear devices such as diodes, bipolar junction transistors, and field-effect transistors. Analysis techniques include modeling diodes, transistors, and operational amplifiers. Biasing, frequency response, and amplifier design will also be studied. Students will explore course concepts in integrated laboratory experiments which include design projects.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in ECE 2342, ENGR 2011, and ENGR 2013.

ECE 2612. Digital Circuit Design. 3 Credit Hours.
This course considers binary number systems, codes, truth tables and the fundamental operation of digital logic circuits. The implementation of combination and sequential digital logic is by a hardware description language in Verilog behavioral synthesis. Complex digital logic and state machine analysis and design are implemented in simulation and programmable gate array hardware.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (ECE 2312, ECE 2332 (may be taken concurrently), or PHYS 1062), ECE 2613 (may be taken concurrently), and ECE 1111.

ECE 2613. Digital Circuit Design Laboratory. 1 Credit Hour.
Laboratory for ECE 2612: Digital Circuit Design. This course provides hands-on experience in digital circuits, gates, flip-flops etc.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in ECE 2612 (may be taken concurrently)

ECE 2922. Honors Electrical Engineering Science II. 3 Credit Hours.
Topics in this course include: sinusoidal analysis, power measurements, three-phase circuits, complex frequency and network functions, resonance, scaling, frequency response, two-port networks, Fourier series and transforms. This Honors course will be challenging and held to a high standard.

Cohort Restrictions: Must be enrolled in one of the following Cohorts: SCHONORS, UHONORS, UHONORSTR.

Course Attributes: HO

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in ECE 2312 (C or higher), ECE 2923 (may be taken concurrently), and MATH 1942.

ECE 2923. Honors Electrical Engineering Science II Lab. 1 Credit Hour.
Topics in this course include: sinusoidal analysis, power measurements, three-phase circuits, complex frequency and network functions, resonance, scaling, frequency response, two-port networks, Fourier series and transforms. This Honors course will be challenging and held to a high standard.

Cohort Restrictions: Must be enrolled in one of the following Cohorts: SCHONORS, UHONORS, UHONORSTR.

Course Attributes: HO

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in ECE 2922 (may be taken concurrently)

ECE 3082. Independent Study in Electrical Engineering. 1 to 3 Credit Hour.
With the department chair's approval, students may complete a regular course during semesters the course is not offered in order to meet prerequisite or graduation requirements. An instructor supervises the student.

Repeatability: This course may be repeated for additional credit.

ECE 3091. Independent Research in Electrical Engineering. 1 to 3 Credit Hour.
Project assigned with the approval of the department chair and conducted under the supervision of a faculty sponsor.

Repeatability: This course may be repeated for additional credit.

ECE 3185. Electrical and Computer Engineering Summer Internship Experience. 1 to 3 Credit Hour.
This course is for an approved, full-time, full-summer (ten weeks or more) work experience in industry or a government agency. The full-time work experience must be carried out during the summer between a full, regular spring semester and full, regular fall semester. The summer employment must entail rigorous engineering analysis at a level comparable to an approved technical elective course in the BS EE program. Work experience in industry, governmental agencies or educational institutions is arranged through the Director of Career Services in the College of Engineering. The course is for one semester of work experience. Letter from supervisor and report by student are required.

Class Restrictions: May not be enrolled in one of the following Classes: Freshman 0 to 29 Credits.

Repeatability: This course may be repeated for additional credit.

ECE 3312. Microelectronics I. 3 Credit Hours.
Students study ideal and non ideal operational amplifier circuits, diodes in nonlinear circuit applications, bipolar junction transistors, field-effect transistors (JFETs), metal oxide semiconductor field effect transistors (MOSFETs), biasing techniques, gain and bandwidth, the design of amplifiers, and transistors as loads.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in (ECE 2322 or ECE 2332) and ECE 3313 (D- or higher; may be taken concurrently)

ECE 3313. Microelectronics I Laboratory. 1 Credit Hour.
Electrical devices and circuits laboratory to be taken concurrently with Electrical Engineering 3312.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in ECE 3312 (D- or higher; may be taken concurrently) and (ECE 2323, ECE 2333, or ECE 2113)

ECE 3412. Classical Control Systems. 3 Credit Hours.
Students will learn the basic theory of analog (classical) control systems. The concept of what constitutes a system is learned as well as how to analyze a system by using input-output pairs. The importance of a transfer function and how it characterizes the behavior of a linear time invariant system will be studied. What a feedback system is and how it may change the behavior of a system is learned. Finally, students will learn how to analyze and design linear time invariant control systems using both time domain and frequency domain techniques.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- (except where noted) in ECE 3512 (C- or higher) and (MATH 2041, MATH 2941, MATH 3041, MATH 3941, or 'Y' in METW)

ECE 3413. Classical Control Laboratory. 1 Credit Hour.
Experimentation on selected topics in ECE 3412: Classical Control Systems.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 3412 (may be taken concurrently)

ECE 3432. Robotic Control using Robotic Operating System (ROS). 3 Credit Hours.
This course covers the steps of building a robot capable of autonomous movement and remote control from start to finish. It is to educate the beginning robot builder and hopefully inspire creativity so that you can design, build, and modify your own robots with the use of the Robotic Operating System (ROS). The skills and concepts taught in this course are presented from an interdisciplinary approach which merges practices in arts and technology. Essential elements of this course are 1) understanding how ROS is used in robotic control, 2) motor drive and sensor integration, 3) Linux-based microcontroller interface, 4) basics of Python programming language, and 5) controlling the robot using control algorithms, signal and image processing, and cloud computing.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (ECE 1111 or CIS 1057)

ECE 3512. Signals: Continuous and Discrete. 4 Credit Hours.
This course covers continuous time signal models, convolution, and superposition integral and impulse response. Students also study Fourier series and periodic signals, Parseval's theorem, energy spectral density, Fourier transform and filters, discrete time signals, difference equations, discrete Fourier transform, and discrete convolution.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (ECE 2322 or ECE 2332) and ENGR 2011.

ECE 3516. Signals and Systems. 5 Credit Hours.
This course is the third in a three-course sequence intended to provide students with foundational knowledge and skills in electrical and computer engineering. In this third course, students will build on concepts learned in Circuits and Electronics I and II to analyze and design signals and systems. Analysis techniques include impulse response, convolution, Fourier series, Fourier transforms, and Laplace transforms. Students will also study discrete-time signals, difference equations, and discrete-time Fourier transform. Students will explore course concepts in integrated laboratory experiments which include design projects.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in ECE 2352 and (MATH 2041, MATH 2941, or 'Y' in METW)

ECE 3522. Stochastic Processes in Signals and Systems. 3 Credit Hours.
To provide the student with an understanding about probability, random variables and random processes and their applications to linear systems. Therefore, the student will learn about the various aspects of probability such as distribution and density functions, conditional probability and various types of random processes such as stationary and nonstationary, ergodic and random processes, the autocorrelation and crosscorrelation, power spectral density, white noise and frequency domain analysis of random signals and their evaluation in linear systems analysis.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in ECE 3512.

ECE 3612. Processor Systems. 3 Credit Hours.
The course focuses on the Atmel 8-bit processor hardware/software architecture through both assembly language programming and C language and its hardware system implementation using the Atmel 324PB microcontroller. Emphasis will be on both C and assembly languages and how they interact with I/O ports and memory. Additional topics include memory addressing modes, stack operations, arithmetic computations, logic operations, subroutine calls, input/output (I/O) interfacing, interrupts, timers, pulse width modulation, A/D conversion, stepper motor control and if time allows I2C protocol. The hybrid flipped/lecture material is supplemented by coordinated homework augmented with videos and in class assignments in both microcontroller simulations and hardware assignments using Atmel Studio 7.0 and the AVR 324PB microcontroller.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- (except where noted) in ECE 2612 (C- or higher), ECE 2613, and ECE 3613 (may be taken concurrently)

ECE 3613. Processor Systems Laboratory. 1 Credit Hour.
This Junior ECE course is the corresponding laboratory for ECE 3612 Processor Systems. The laboratory assignments utilize Atmel AVR microcontroller simulations using Atmel Studio 6.1 and hardware experiments with the Atmel 169P Butterfly microcontroller. Labs will cover reading and writing to memory, stack operations, LED's on I/O ports, PWM for servo motor control, timers and counters.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 3612 (may be taken concurrently)

ECE 3614. Printed Circuit Board Design. 3 Credit Hours.
The course introduces students to manufacturing and soldering techniques used in the design of Printed Circuit Boards (PCBs). The design of PCBs will center around using the KiCad Electronic Design Automation (EDA) tool. KiCad will be used to design 1-and 2-layer PCBs from electronic schematic capture followed by the board layout and track routing techniques. Students will gain hands-on experience in the manufacturing process by populating and soldering components to the PCB. Students will learn industry standard design and measurement techniques allowing them to construct PCBs that use both Surface Mounted Devices (SMD) and Plated Thru-Hole (PTH) components.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 3612 (may be taken concurrently) and ECE 3613 (may be taken concurrently)

ECE 3622. Embedded System Design. 3 Credit Hours.
This course and co-requisite laboratory considers embedded systems in digital process control and digital signal processing using the Verilog hardware description language and behavioral synthesis using the programmable gate array. Topics include: the controller-datapath construct, nested modules, soft core processing elements, fixed and floating point arithmetic calculations in programmable hardware, interfacing to hard core peripherals and soft core microprocessors.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 3612, ECE 3613, and ECE 3623 (may be taken concurrently)

ECE 3623. Embedded System Design Laboratory. 1 Credit Hour.
Laboratory for ECE 3622 (0245): Embedded System Design.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 3622 (may be taken concurrently)

ECE 3712. Introduction to Electromagnetic Fields and Waves. 3 Credit Hours.
Engineering applications of electromagnetic field theory including Coulomb's Law, Gauss' Law and Faraday's Law and applications of Poisson's equations with boundary values, Magnetic flux and the use of Gauss' and Ampere's Laws. The course will also consider transmission lines, the development of Maxwell's equations and the transmission of plane waves in free space and uniform, homogenous, isotropic media.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in PHYS 1062, (ECE 2322 or ECE 2332), and (ENGR 2011 or MATH 2101)

ECE 3722. Electromagnetic Wave Propagation. 3 Credit Hours.
This course considers the application of the time-harmonic Maxwell's equations to electromagnetic wave propagation, transmission lines, wave guides, antenna, and methods for numerical analysis. Matlab and computer aided design software is used for simulation of electromagnetic wave propagation in engineering applications.

Co-requisites: ECE 3723.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 3712.

ECE 3723. Electromagnetic Wave Propagation Laboratory. 1 Credit Hour.
Laboratory for ECE 3722 (0222): Electromagnetic Wave Propagation.

Co-requisites: ECE 3722.

Repeatability: This course may not be repeated for additional credits.

ECE 3732. Electromechanical Energy Systems. 3 Credit Hours.
Fundamentals of electromechanical energy conversion, electromechanical devices, and systems. Energy state functions, force-energy relationships, basic transducers, and introduction to AC and DC machines. DC motors and generators, synchronous motors and generators, induction motors, and transformers.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in ECE 3733 (D- or higher; may be taken concurrently), (ECE 2322, ECE 2332, or ECE 2112), and (ECE 2323, ECE 2333, or ECE 2113)

ECE 3733. Electromechanical Energy Systems Laboratory. 1 Credit Hour.
This course provides hands-on experience on various types of electrical machines, such as DC and AC motors and generators, and transformers. Experiments include operation of transformers, motors and generators, control of motor speed, and loading of generators. Computer data acquisition system is utilized for interface.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in ECE 3732 (D- or higher; may be taken concurrently) and (ECE 2333, ECE 2323, or ECE 2113)

ECE 3822. Engineering Computation II. 3 Credit Hours.
The primary goal for this course is to teach engineers how to solve problems of scale using a variety of computer tools. The three main goals of this course are: (1) introduce students to the hierarchy of software tools (e.g., scripting languages, interpreted languages, compiled languages) used to solve engineering problems; (2) introduce the basics of Python, a scripting language that is a dominant tool in engineering; and (3) introduce Java, object-oriented design, and a number of Java-related software tools that automate testing, documentation and cross-compilation into web applications. A common thread throughout these topics is the decomposition of large-scale problems into smaller problems that can be solved using reusable modules. Good software engineering practices will be stressed throughout the course. The latter part of the course will involve developing a significant computer simulation of a real-world engineering system that involves real data and utilizes both Python and Java.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (CIS 1057 or ECE 1111) and ENGR 2011.

ECE 3824. Engineering Computation III. 3 Credit Hours.
Electrical and computer engineers are increasingly interacting with the Internet as part of the technology development process. This requires a complex set of software skills that includes knowledge of operating systems and cloud computing, web programming and graphical user programming. Engineers today are also expected to participate in large software development projects that use integrated development environment tools to interact with Internet-based code repositories and agile development methodologies. In this project-based course, students will learn how to (1) work in a cloud-based environment using the Linux operating system, (2) develop complex software systems using object-oriented design in C++, (3) program using interpretive languages such as Python, (4) develop user interfaces and Internet-aware software using Python, and (5) manage complex software projects using contemporary tools such as GitHub and Taiga.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (ECE 1111 or CIS 1057)

ECE 3912. Honors Signals: Continuous and Discrete. 4 Credit Hours.
This course covers continuous time signal models, convolution, and superposition integral and impulse response. Students also study Fourier series and periodic signals, Parseval's theorem, energy spectral density, Fourier transform and filters, discrete time signals, difference equations, Z transforms, and discrete convolution. This honors course will be very challenging.

Cohort Restrictions: Must be enrolled in one of the following Cohorts: SCHONORS, UHONORS, UHONORSTR.

Course Attributes: HO

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (ECE 2322 or ECE 2332)

ECE 3914. Honors Microprocessor Systems. 3 Credit Hours.
Students study finite-state machines in process control, assembly language programming of the Intel i186EX 16-bit microprocessor and its hardware system implementation. Additional topics include: dynamic RAM read/write and DMA access, hardware interrupts, I/O port addressing, peripheral interface design, microprocessor addressing modes, op codes, and arithmetic computation. A stimulating and challenging Honors course.

Cohort Restrictions: Must be enrolled in one of the following Cohorts: SCHONORS, UHONORS, UHONORSTR.

Course Attributes: HO

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in ECE 2612, ECE 2613 (D- or higher), (ECE 2922 or ECE 2332), and ECE 3915 (D- or higher; may be taken concurrently)

ECE 3915. Honors Microprocessor Systems Lab. 1 Credit Hour.
This course is the hardware and software laboratory in microprocessor systems.

Cohort Restrictions: Must be enrolled in one of the following Cohorts: SCHONORS, UHONORS, UHONORSTR.

Course Attributes: HO

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 3914 (may be taken concurrently)

ECE 3916. Honors Signals and Systems. 5 Credit Hours.
This course is the third in a three-course sequence intended to provide students with foundational knowledge and skills in electrical and computer engineering. In this third course, students will build on concepts learned in Circuits and Electronics I and II to analyze and design signals and systems. Analysis techniques include impulse response, convolution, Fourier series, Fourier transforms, and Laplace transforms. Students will also study discrete-time signals, difference equations, and discrete-time Fourier transform. Students will explore course concepts in integrated laboratory experiments which include design projects. This honors course will require students to complete a more in-depth design for these projects.

Cohort Restrictions: Must be enrolled in one of the following Cohorts: SCHONORS, UHONORS, UHONORSTR.

Course Attributes: HO

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in ECE 2352 and (MATH 2041, MATH 2941, or 'Y' in METW)

ECE 4110. Special Topics. 1 to 4 Credit Hour.
Topics vary by semester. See the course schedule for the specific topic each semester.

Field of Study Restrictions: Must be enrolled in one of the following Majors: Civil Engineering, Electrical Engineering, Engineering, Mechanical Engineering.

Repeatability: This course may be repeated for additional credit.

ECE 4176. Senior Design Project I: ECE. 3 Credit Hours.
This is the designated discipline-specific design course for the BSEE program which will be taken in the senior year. It is the first course of a two-semester senior design sequence intended for electrical engineering majors. Students will develop and practice skills and techniques for managing and executing engineering design projects within a team. The goals for this course will be for each team to build a prototype, measure system performance, and communicate results to peers, sponsors, and faculty. At completion of ECE 4176, students will have the flexibility to continue with the same topic or choose a completely new topic in the follow-on course ENGR 4296: Capstone Senior Design Project. Project requirements for ENGR 4296 will be adjusted depending on whether students elected to continue with the same topic or choose a new topic.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- (except where noted) in (ECE 3612 or ECE 3914), (ECE 3613 or ECE 3915), (ECE 3412, ECE 3522, ECE 3622, ECE 3712, or ECE 3822), and (ECE 3512 (C- or higher), ECE 3912 (C- or higher), ECE 3516 (C- or higher), or ECE 3916 (C- or higher))

ECE 4312. Microelectronics II. 3 Credit Hours.
This course emphasizes solving software design problems as well as advanced study of electronic devices and their application to linear, non-linear, and digital circuits. Further topics include: transistors, FET's filters, oscillators, amplifiers, A/D, D/A, some integrated circuits, and VLSI systems.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 3312.

ECE 4322. VLSI Systems Design. 3 Credit Hours.
This course introduces the hierarchical design methodology of VLSI and the study of basic logic elements and design methods in MOS and CMOS, as well as the physics of MOS devices and the fabrication process. Design rules and computation of circuit parameters from layout, and system level design are further topics.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in ECE 3312.

ECE 4412. Modern Control Theory. 3 Credit Hours.
Analysis and design of control systems using state variable techniques, including discrete and continuous state variable analysis, linear vector spaces, eigenvalues, eigenevectors, controllability, observability, stability, state feedback design, and observer design.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 3412.

ECE 4422. Digital Control Systems. 3 Credit Hours.
Subjects for this course include: discrete data and digital control systems, signal conversions and processing, the Z transform and state variable techniques applied to digital control system, time and frequency domain analysis techniques, stability of digital control systems, etc. The students are required to design and implement a digital control system in groups and are assigned with different tasks.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 3412.

ECE 4442. Introduction to Engineering Optimization. 3 Credit Hours.
Optimization aims at maximizing or minimizing an objective in the presence of complicating constraints. This course will cover fundamental concepts and methods in optimization and their applications in engineering systems. The focus will be on linear and nonlinear systems of equations, unconstrained optimization, equality-constrained optimization, and inequality-constrained optimization, with applications in engineering systems. Topics include formulation of nonlinear optimization problems, optimality conditions for convex optimization, review of classical optimization techniques, and illustrative examples from various fields of engineering. The goal is to maintain a balance between theory, numerical computation, problem setup for solution by optimization software, and applications to engineering systems.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (MATH 2041, MATH 2941, MATH 3041, MATH 3941, or 'Y' in METW) and ENGR 2011.

ECE 4512. Digital Communication Systems. 3 Credit Hours.
This course and co-requisite laboratory considers techniques of digital signaling and data communication with amplitude, frequency and phase modulation and demodulation in the presence of noise using MATLAB/Simulink simulation. Topics include: the optimum correlation receiver in baseband and bandpass systems, binary and multiple level signaling, time and frequency division multiplexing, error detection and correction, analog-to-digital conversion and traditional analog amplitude and frequency modulation.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 3522 and ECE 4513 (may be taken concurrently)

ECE 4513. Digital Communication Systems Laboratory. 1 Credit Hour.
Laboratory for Electrical Engineering 4512: Digital Communication Systems.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 4512 (may be taken concurrently)

ECE 4522. Digital Signal Processing. 3 Credit Hours.
Course topics include: Discrete-time signals and systems, Random signals, Sampling process, Digital processing of analog signals, Discrete-time Fourier Transforms (DTFT), Filter types and characteristics, Filter design, Finite Impulse Response (FIR) systems, linear phase FIR filters, Infinite Impulse Response (IIR) systems, Discrete Fourier Transforms (DFT), Fast Fourier Transform (FFT), Circular convolution, Transfer functions, and Applications of digital signal processing.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 3522.

ECE 4526. Introduction to Computer Intrusion and Detection of Cyber Physical Security. 3 Credit Hours.
This is an introductory course to computer and system intrusion and detection techniques for cyber physical security (CPS). Students will learn hardware/firmware security and hardware reverse engineering, gaining theoretical and practical knowledge to analyze critical security vulnerabilities of Industrial Control Systems (ICS), in wired and wireless environment - the backbones of any cyber physical systems. Students will learn case studies from actual ICS attacks and run hands-on exercises and tools of being all the 'hats' - red, blue, and white.

Degree Restrictions: Must be enrolled in one of the following Degrees: Bachelor Sci in Engineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 4532.

ECE 4527. Introduction to Machine Learning and Pattern Recognition. 3 Credit Hours.
Pattern recognition theory and practice is concerned with the design, analysis, and development of methods for the classification or description of patterns, objects, signals, and processes. At the heart of this discipline is our ability to infer the statistical behavior of data from limited data sets, and to assign data to classes based on generalized notions of distances in a probabilistic space. Many commercial applications of pattern recognition exist today, including voice recognition, fingerprint classification, and retinal scanners. Recent developments in statistical modeling using deep learning have accelerated the growth of pattern recognition applications. The objective of this course is to introduce fundamental methods of pattern recognition, both statistical and neural, with examples from several application areas.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (ECE 3512 or ECE 3912) and ECE 3522.

ECE 4528. Introduction to Cryptography for Cyber Physical Security. 3 Credit Hours.
This is an introductory course to the theory and practice of cryptography used in security for cyber physical systems or Cyber Physical Security (CPS). Cyber physical systems are built upon Industrial Control Systems (ICS) and have a unique set of challenges with the need to support security in three key operations: real-time protection, SCADA (supervisory control and data acquisition), and engineering access (event log). The course starts with cryptography foundations and principles. The course then covers various cryptographic primitives, algorithms, intrusion attacks, security protocols, crypto devices and hardware, government standards, and case studies, specific for CPS needs.

Degree Restrictions: Must be enrolled in one of the following Degrees: Bachelor Sci in Engineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 4532.

ECE 4532. Data and Computer Communication. 3 Credit Hours.
This course considers wired and wireless data transmission, communication networks and protocols, error detection and correction coding, spread spectrum modulation and demodulation. Topics include protocol architectures, flow and error control, multiplexing, code division multiple access 4G LTE cellular systems and embedded Ethernet.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in ECE 3522 (D- or higher) and (CIS 1057 or ECE 1111)

ECE 4542. Telecommunications Engineering. 3 Credit Hours.
This course considers digital data communication with complex modulation and error detection and correction in the presence of noise using MATLAB/Simulink simulation. Topics include: quadrature amplitude and continuous phase modulation, frequency hopping and spread spectrum modulation, linear, block, cyclic, convolutional and CRC codes, fading and multipath interference, Doppler shift in mobile environments and the performance of cellular and wireless communication systems.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 4512.

ECE 4574. Introduction to Cisco Certificate Preparation. 3 Credit Hours.
This course introduces/prepares students to become certified as a Cisco Certified Entry Network Technician (CCENT). CCENT-certified professionals have the knowledge and skill to install, operate, and troubleshoot a small enterprise branch network, including basic network security. The course includes a hands-on lab equipped with Cisco networking equipment, access to the powerful Cisco Packet Tracer networking simulation software, as well as access to the online courses at Cisco Networking Academy. Students who complete the online curricula will receive a discount voucher to reduce the cost of the CCENT exam. Students who wish to prepare to become certified in the Cisco Certified Networking Associate program may take other follow-up courses.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in ECE 4532 (may be taken concurrently)

ECE 4612. Advanced Processor Systems. 3 Credit Hours.
This course focuses on Verilog hardware description language and its applications to digital hardware system design including CPU and memory, as well as synchronous and asynchronous events and multitasking in the design of computational and data communication processors. The course will also consider computer-aided-design software and simulators, and hardware description language compilers.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of D- in ECE 3612 and ECE 3613.

ECE 4712. Power System Analysis. 3 Credit Hours.
This course introduces the modern power systems and its changing landscape. Topics include the basics of power generation, transmission and distribution, power flow, economic dispatch, transient and stability analysis, short circuit analysis, and HVDC systems.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (ECE 2322 or ECE 2332)

ECE 4722. Power Electronics. 3 Credit Hours.
This course introduces the basics of power electronic circuits and their applications in modern power systems. Topics include converters and inverters, and their applications in power systems. Course material covers DC-DC converters in buck and boost topologies, and their analysis; AC-DC rectification and control; DC-AC inverters and their applications in voltage and frequency control; three-phase inverters and HVDC transmission. This course will use Matlab/Simulink simulation for student projects and homework.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in ((ECE 2332 and ECE 2333), (ECE 2112 and ECE 2113), or (ECE 2322 and ECE 2323))

ECE 4822. Engineering Computation IV. 3 Credit Hours.
In this course, students will study the implementation of parallel processing algorithms on graphics processing units (GPUs). This course has three main components: an overview of processor architectures, a study of parallel algorithms and hands-on experience with programming Nvidia GPUs using popular software libraries such as CUDA. Students will be expected to program in C/C++ and Python and have experience with the Linux operating system.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (ECE 3822 or CIS 2168)

ECE 5022. Engineering Analysis and Applications. 3 Credit Hours.
Vector space, basis, projection, null space, function space, L2 and space of continuous functions, Hilbert space, orthogonality, generalized Fourier series, linear transformation, adjoint transformation, eigenvalue problem, linear functional, Gateaux and Frechet differential, constrained optimization, infinite dimensional systems, complex analysis.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5033. Probability and Random Processes. 3 Credit Hours.
Sets and events, Random variables, Distribution and density functions, Functions of multiple random variables, Moments and conditional statistics, Information entropy, stochastic processes, wide-sense stationary process, ergodicity, correlation, and power spectrum of stationary processes. Applications to sampling theory and signal modulation and detection.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5110. Special Topics in Electrical and Computer Engineering. 3 Credit Hours.
Selected topics on current technologies in various research areas under electrical and computer engineering.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 5116. Spacecraft Systems Engineering. 3 Credit Hours.
The concept of systems engineering is introduced using a satellite application. Systems engineering is a top-down approach to the design, implementation, testing, and deployment of large-scale systems to meet the needs of users. The topics will include systems engineering methodology, dynamics of spacecraft, and celestial mechanics. This course will also introduce the notion of invention and innovation, and how they are related to the intellectual property issues.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5314. Microelectronics. 3 Credit Hours.
Advanced study of electronic devices and their applications to linear, non-linear, and digital circuits; transistors, FET's, amplifiers, digital integrated circuits, and VLSI's; Software design emphasized. A term project will be assigned. NOTE: Students cannot earn credit for both ECE 4312 and ECE 5314.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5324. VLSI System Design and Testing. 3 Credit Hours.
An introduction to a hierarchical design methodology of VLSI; study of basic logic elements and design methods in nMOS and CMOS; development of testable designs; the physics of MOS devices and fabrications processes; design rules and computation of circuit parameters from layout; system level design techniques; circuit structures with built-in self-test, design-for-test and self-checking features. NOTE: Students cannot earn credit for both ECE 4322 and ECE 5324.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in ECE 5314.

ECE 5344. Fundamentals of Bio-MEMS and Biomedical Microdevices. 3 Credit Hours.
The course introduces the basic concepts for design and principle of bio-micro-electro-mechanical systems (BioMEMS) and biomedical micro-integrated systems. Wireless communication in context to biomedical devices are described. Microelectronics process modules used in the design and fabrication of MEMS and micro-integrated systems are presented. Applications of these systems in a variety of sensors and transducers are considered. Recent advances in biomedical applications of MEMS are discussed in detail.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5412. Control System Analysis. 3 Credit Hours.
Review of control concepts and application; state space representation of dynamical systems; controllability, observability; time invariant and time varying systems, design of full state feedback and output feedback systems; eigenstructure assignment; the linear quadratic regulator; Kalman filter; estimation and filtering; robust control via eigenstructure design, Kharitonov theorem, application examples.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5432. Game Theory and Applications in Engineering. 3 Credit Hours.
The course covers the basic framework for strategic games and its various manifestations. Topics include matrix games, extensive form games, mixed strategies, repeated games, Bayesian games, and cooperative games. The course continues with various applications of game theory in engineering systems. The course also covers applications of game theory as a design tool for engineering multi-agent systems, i.e., systems that are comprised of a collection of programmable decision-making components.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5442. Engineering Optimization: Methods and Applications. 3 Credit Hours.
Optimization aims at maximizing or minimizing an objective in the presence of complicating constraints. This course will cover fundamental concepts and methods in optimization and their applications in engineering systems. The focus will be on linear and nonlinear system of equations, unconstrained optimization, equality-constrained optimization, and inequality-constrained optimization, with applications in electrical engineering systems. Topics include, but are not limited to, formulation of nonlinear optimization problems, optimality conditions for convex optimization, review of classical optimization techniques, and illustrative examples from electric power systems. Numerous applications from various fields of engineering are presented. The goal is to maintain a balance between theory, numerical computation, problem setup for solution by optimization software, and applications to engineering systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5512. Introduction to Digital Communications. 3 Credit Hours.
Baseband pulse, digital, and passband communications systems; properties and bandwidth of signals and noise; detection of signals in noise; signal-to-noise ratio (SNR); distortionless transmission and intersymbol interference; pulse code modulation; amplitude, phase and frequency modulation and demodulation; simulation of communication systems. NOTE: Students cannot earn credit for both ECE 4512 and ECE 5512.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5514. Digital Signal Processing Analysis. 3 Credit Hours.
Topics covered are: various types of digital signal processing (DSP) techniques such as convolution, correlation, and filtering, as well as Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) all pass and comb digital filters, the Discrete Fourier Transform, and the use of MATLAB as a tool for DSP software tasks. A term project will be assigned. NOTE: Students cannot earn credit for both ECE 4522 and ECE 5514.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5516. Introduction to Communication Networks. 3 Credit Hours.
Introduction to Internet and TCP and IP protocols, telephone networks, Local Area Networks, packet switching, ATM, and other related topics. NOTE: Students cannot earn credit for both ECE 4532 and ECE 5516.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5526. Engineering Principles of Computer Intrusion and Detection. 3 Credit Hours.
This course provides an introduction of computer intrusion and detection techniques. It gives theoretical and practical foundations necessary to continue further learning of computer security. We will study and analyze critical security vulnerabilities of software design and network and information systems. The learned skills are widely used by IT security analysts in industries. At the end of the class the students will be able to understand basic concepts of intrusion detection and traffic analysis from a practical point of view. This course will provide the tools and knowledge necessary to continue further learning in computer security and advance further in the profession.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in ECE 5516.

ECE 5528. Introduction to Cryptography and Information Security. 3 Credit Hours.
This course covers the theory and practice of computer communications security. Topics include symmetric encryption, public and private key cryptography, message digests, digital signatures, secure email, and various types of authentication methods. We will review various cryptographic primitives, algorithms, intrusion attacks, and security protocols.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5538. Hardware and Industrial Control System Security. 3 Credit Hours.
This course covers the theory and practice of hardware and control system security. Topics include digital system security, side channel attacks on cryptographic systems, industrial control system security, and intellectual property protection. We will review hardware implementation of cryptographic primitives, secure hardware design, and security protocols. Note: Credits of this course will not apply to MSEE and PhD (EE) degree programs unless preapproved.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in ECE 5528.

ECE 5541. Hardware Security Lab. 3 Credit Hours.
This laboratory includes a university version of wired (with internet protocol suite of packets and layers) and wireless (with IEEE802.11 layers) equipment and physical network along with open source network security software. Depending on the application, the lab provides students flexibility to fully analyze protocols and security vulnerability with respect to the network, Programmable Logic Controller (PLC), and power grid, etc. Students gain hands-on experience from role-playing both as a black-hat hacker by instigating attacks and a white-hat hacker by performing digital forensics and penetration tests. Note: Credits of this course will not apply to MSEE and PhD (EE) degree programs.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5548. Secure Computer Memory Architecture and Intrusion Prevention Methodologies. 3 Credit Hours.
This course covers physical computer memory organization and areas of vulnerability such as susceptibility to buffer overflow and Direct Memory Access (DMA) attacks. An overflow attack happens when the data written to a physical memory exceeds its allocated buffer size, which is in violation of memory safety rules. DMA happens when a data transfer is done via direct physical memory access, thus bypassing operating system's supervision. Such a "back door" access is intended to increase the hardware performance throughput but inadvertently creates a major hole in system security. This course analyzes physical memory design methodologies to prevent such intrusions. Note; Credits of this course will not apply to MSEE and PhD (EE) degree programs.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5558. Reverse Engineering. 3 Credit Hours.
This course covers methodologies, equipment and software tools used to extract information and build knowledge from sophisticated modern-era hardware and software systems for reverse engineering purposes. Some systems require invasive and destructive technique to get to the source of the information, while for others, non-invasive monitoring and fault injection are sufficient methods. Reverse engineering equipment and tools include but are not limited to debuggers, disassemblers, logic analyzers, oscilloscopes, and simulators. Note: Credits of this course will not apply to MSEE and PhD (EE) degree programs.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5562. Wireless Communications Engineering. 3 Credit Hours.
This course provides a comprehensive introduction of physical-layer wireless communications, including: Cellular concepts; Wireless channel modeling; Modulation techniques; Multiple access techniques; Channel coding and wireless system capacity; Receiver diversity; Transmit diversity and multiple-input multiple-output (MIMO) technology; Equalization; Orthogonal frequency division multiplexing (OFDM); Wireless systems and standards, and latest developments in wireless technologies.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5564. Cloud Computing Security. 3 Credit Hours.
This course first introduces students to the essentials of a cloud computing environment: technologies, infrastructure, platforms, and application software. Students then build a cloud computing system to monitor its vulnerability, build security measures, and attack it to further refine the security solution. OpenNebula Systems, an open source cloud computing management toolkit and a commercial cloud computing service, will be used for the exercises.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5566. Forensics for Cyber Physical Systems Security. 3 Credit Hours.
This course first introduces students to the construct of today's cyber physical system, which is an integration of software and hardware (cyber and physical), built upon an infrastructure of communications network. Cyber physical systems are an integral part of our daily lives that must deliver ultimate safety, security, and reliability, such as in automotive, medical, transportation, power, water, and nuclear energy systems. Therefore, an attack on any such system can be catastrophic. We will analyze hardware components and structure and study their vulnerability to exact forensic artifacts, and why it is important to have trust-worthy hardware, starting from secure integrated circuit design and manufacturing as a baseline. Tools will be used in investigation and forensic analysis. Advanced topics go beyond identification of the attack vector and region, and root causes by researching on self-monitoring, self-repair and self-healing hardware.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5568. Engineering Project Quality and Risk Management, and ISO Standards. 3 Credit Hours.
This course covers quality and risk management which are under the umbrella of project management, both go hand-in-hand to ensure best practices for engineering for products. Four components of quality management are quality planning, quality assurance, qualify control and quality improvement. Also covered is ISO9001, quality management systems standards. Risk management includes enterprise risk management strategy, risk assessment, risk responses, risk communication and awareness training, and risk acceptance. Also covered is ISO 27001 and 2 on information security standards and best practices.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5572. Certificate Preparation - (ISC)2/CISSP-Information Systems Security. 3 Credit Hours.
The International Information Systems Security Certification Consortium (ISC)2 is a non-profit organization that specializes in information security certifications, which demonstrate certificate owners' competence in the subject manner. (ISC)2 is known as the "world's largest IT security organization" and among its certificates, Certified Information Systems Security Professional (CISSP) is the most widely valued. This course covers preparation for the CISSP-ISSEP certification, where ISSEP (Information System Security Engineering Professional) focuses on engineering aspects of the CISSP. The ISSEP exam focuses on four areas of information security: (1) Systems Security Engineering, (2) Certification and Accreditation (C&A) / Risk Management Framework (RMF), (3) Technical Management, and (4) United States Government Information Assurance Related Policies and Issuances. Note: Credits of this course will not apply to MSEE and PhD (EE) degree programs.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5574. Certificate Preparation - Cisco Networking Academy. 3 Credit Hours.
This course uses Cisco Networking Academy material to cover various Cisco Certified Network Security topics concentrating on network security principals, tools, and configurations, and includes a hands-on lab equipped with Cisco networking equipment. Note: Credits of this course will not apply to MSEE and PhD (EE) degree programs

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5575. Capstone Project. 3 Credit Hours.
A Capstone Project is a work-study project where a student with support from his/her sponsoring entity works on a current or emerging challenge on cybersecurity. Engineering Resilient Systems (ERS) is an example of a DoD sponsored Capstone Project. Through Capstone Project, a student will develop tools and procedures to produce a complete and robust product requirement, make efficient and effective engineering decisions, consider manufacturability of a system design, and establish a baseline resiliency including Tactics, Techniques, and Procedures (TTP) against threats. Note: Credits of this course will not apply to MSEE and PhD (EE) degree programs.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5600. Graduate Seminar. 0 Credit Hours.
Required seminar for graduate students in Electrical and Computer Engineering for scientific and professional development. Speakers for these seminars include prominent researchers from academic and professional backgrounds. Students will be graded on participation of at least 70% of the bi-weekly seminars during the semester.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 5612. Advanced Processor Systems. 3 Credit Hours.
Hardware description language (Verilog) design of processor systems for digital signal processing and data communication. Projects will be assigned in simulation and synthesis of dataflow and processor architectures targeting field programmable gate arrays (FPGA). NOTE: Students cannot earn credit for both ECE 4612 and ECE 5612.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5622. Introduction to Computer Architecture. 3 Credit Hours.
Instruction set architectures, Register Transfer Level hardware description. Data-path design. Controller design. Caches and memory systems. Addressing. Microprogramming. Computer arithmetic. Survey of current computers and microprocessors. Projects will include Verilog/VHDL implementation of data-path components and testing them on FPGAs.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5712. Power Systems Engineering. 3 Credit Hours.
This course introduces the modern power systems and its changing landscape. The course covers the basics of power generation and transformers, and an introduction to power electronic devices, AC transmission and distribution, power flow, economic dispatch, transient and stability analysis, short circuit analysis, and HVDC systems, power system protection, power market deregulation. NOTE: Students cannot earn credit for both ECE 4712 and ECE 5712.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5714. Introduction to Intelligent Systems Engineering. 3 Credit Hours.
Introduction of the use of artificial intelligence techniques to develop intelligent systems. The course gives the student 1) an overview of what artificial intelligence is and its current state; 2) an overview of intelligent systems --what they are and their possible future role in society; 3) a practical and theoretical knowledge of expert systems, their development, implementation and maintenance and 4) an introduction to intelligent tutoring systems and to provide a perspective about the potential impact of these systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5716. Power System Economics. 3 Credit Hours.
This course aims at enriching course offerings for graduate students who would like to have a focus on electric energy. We will discuss major problems in power system economics, such as: optimization formulations and solutions; competition; bidding strategies; locational marginal prices; ancillary services; and investment decisions.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in ECE 5712.

ECE 5722. Power Electronic Devices and Systems. 3 Credit Hours.
This course introduces power electronic devices and circuits, and their applications in modern power systems. Topics include DC-DC converters in buck and boost topologies, and their modeling and feedback control; AC-DC rectification and control; DC-AC inverters, modeling, and voltage and frequency control; Three-phase inverters, and HVDC transmission. This course will use Matlab/Simulink simulation for student projects and homework. NOTE: Students cannot earn credit for both ECE 4722 and ECE 5722.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5732. Electric Machines and Drives. 3 Credit Hours.
Fundamentals of electromechanical energy conversion, electric drives and systems. Transformers, DC machines, synchronous machines, induction motors, dq-transformation, vector control of induction motors, reluctance motors, single phase motors, brushless dc motor. Introduction to power electronics and their applications in power drives.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 5742. Power Converter Modeling and Control. 3 Credit Hours.
This course introduces modeling and control methodologies of modern power electronic systems and their applications. The course covers modeling of DC-DC, DC-AC, AC-DC and AC-DC-AC power electronic converters, conventional and advanced control diagram design of power converters, interactions among multiple converters in power electronics dominated systems. Also industrial and grid-level applications of these technologies will be discussed.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B in (ECE 5722 or ECE 4722)

ECE 5752. Power Electronics Design and Testing. 3 Credit Hours.
This course focuses on the design and testing perspectives of power electronics technologies. Particularly, the course introduces the popular software environment for power electronics testing and introduces the detailed steps and procedures of power electronics simulation model development. The course emphasizes topology, modulation, and control of power electronic converters, and also highlights some selected applications for simulation testing. Lab sessions will also be arranged for hardware testing of power electronics technologies. The major goal of this course is to let the students know how power electronic converters are used and tested in real-world applications.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B in ECE 5722.

ECE 5826. Information Theory. 3 Credit Hours.
Information Theory is a field that has been central to the development of modern communications and computing technologies. The goal of this course is to provide the student with a thorough understanding of the concepts of entropy and information, and how to apply these to real world problems such as speech recognition, language engineering, signal compression, and financial modeling. A secondary goal is to develop a mathematically rigorous understanding of methods for measuring and manipulating various measures of information in signals and systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in ECE 3522.

ECE 5999. Research Experience in Electrical Engineering. 0 Credit Hours.
Research Experience provides graduate students laboratory experiences/research practices prior to undertaking independent, directed, master project, master's thesis, or dissertation research. This course allows graduate students the opportunity to learn the use of laboratory equipment, designing and carrying out an experiment(s), collecting preliminary data, field experiences, and participation in laboratory meeting, etc. with faculty which may lead to identifying a faculty mentor. The course will be graded Pass (P) or Fail (F). The Research Experience is a non-repeatable course. After the completion of ECE 5999 - Research Experience in ECE, students will need to be enrolled in independent study, directed research, master's research, master's thesis, dissertation proposal, or dissertation if they continue in an active research program.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 8110. Special Topics in Electrical and Computer Engineering. 3 Credit Hours.
Selected advanced topics in various major research areas under electrical and computer engineering.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 8324. Mixed Signal VLSI Design. 3 Credit Hours.
Basic MOS device physics, single state amplifiers, frequency response, op amps, switched capacitor circuits, short-channel effects, amplifier design for wireless communication, low power static RAM architectures, layout and packaging.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in ECE 5324.

ECE 8334. Nano Applications, MEMS & NEMS. 3 Credit Hours.
Nano challenges, quantum mechanics, nano materials, nanolithography, optics, carbon nanotubes, GaNa nanotechnology, MEMS and NEMS Architectures, Mathematical Model of MEMS and NEMS, Applications of Nanotechnology: Bio-Medical applications, Optical Devices, Sensors.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in ECE 5324.

ECE 8412. Optimal and Robust Control. 3 Credit Hours.
Concept of optimality, calculus of variations, Euler-Lagrange equation, Pontryagin's minimum principle, Bellman's equation, Kalman filter, uncertainties in physical systems; structured and unstructured uncertainties; application of the Lyapunov method to robust control problems; robust optimal control; state space design for finite and infinite horizon problems; H-infinity design.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in ECE 5412.

ECE 8414. Adaptive Control. 3 Credit Hours.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 8512. Signal Processing and Communication Theory. 3 Credit Hours.
Coherent and non-coherent detection of binary and M-ary signals in noise; waveform coding, linear block coding; convolutional, cyclic and turbo codes; error probability and bandwidth-efficiency plane in the design of digital communications systems; multipath and fading channels; simulation of communication systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in (ECE 5512 and ENGR 5033)

ECE 8514. Applications in Digital Signal Processing. 3 Credit Hours.
FIR and IIR digital filter design, finite word length effects, filter banks, multirate signal processing, spectral analysis (classical, modern, parametric and nonparametric techniques), adaptive filtering (Wiener filter theory) and speech production, analysis, and processing tools and speech coding. Computer experiments using MATLAB will be an integral part of the course.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in ECE 5033.

ECE 8516. Design and Performance of Communication Networks. 3 Credit Hours.
An overview of the technologies, architectures and protocols used to build high-speed communication networks. Design and performance analysis techniques for computer communication networks. Topics will include: design and performance analysis of wired and wireless local networks, sensor networks, and Internet. Projects will include developing stochastic models, queuing analysis, and simulations.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 8524. Speech Signal Processing. 3 Credit Hours.
Spectral analysis of non-stationary signals, short-time Fourier transform, homomorphic filtering and filter bank, Speech compression, and synthesis techniques. Weiner filtering for speech enhancement.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in ECE 8514.

ECE 8525. Fundamentals of Speech Recognition. 3 Credit Hours.
This course introduces students to the theory and implementation of modern day speech recognition systems. We begin with a review of pattern recognition and machine learning, including topics such as Gaussian mixture models and Bayesian models. We then discuss the three main components of a speech recognition system: feature extraction, acoustic modeling and language modeling. We conclude the course with an overview of state of the art systems. Students will learn how to simulate and evaluate complex machine learning algorithms such as hidden Markov models and neural networks. Data-driven methodologies will be emphasized.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in ENGR 5022 and ENGR 5033.

ECE 8526. Information Theory. 3 Credit Hours.
Information Theory is a field that has been central to the development of modern communications and computing technologies. The goal of this course is to provide the student with a thorough understanding of the concepts of entropy and information, and how to apply these to real world problems such as speech recognition, language engineering, signal compression, and financial modeling. A secondary goal is to develop a mathematically rigorous understanding of methods for measuring and manipulating various measures of information in signals and systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in ENGR 5022 and ENGR 5033.

ECE 8527. Introduction to Machine Learning and Pattern Recognition. 3 Credit Hours.
Pattern recognition theory and practice is concerned with the design, analysis, and development of methods for the classification or description of patterns, objects, signals, and processes. At the heart of this discipline is our ability to infer the statistical behavior of data from limited data sets, and to assign data to classes based on generalized notions of distances in a probabilistic space. Many commercial applications of pattern recognition exist today, including voice recognition, fingerprint classification, and retinal scanners. Recent developments in statistical modeling using Bayesian techniques, neural networks, decision trees, fuzzy logic, and syntactic structures have accelerated the growth of pattern recognition applications. The objective of this course is to introduce fundamental methods of pattern recognition, both statistical and neural, with examples from several application areas.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in ENGR 5022 and ENGR 5033.

ECE 8528. Advanced Topics in Statistical Modeling for Engineering Applications. 3 Credit Hours.
This course builds on a basic knowledge of machine learning and reviews recent advances in the field. It is a research-oriented course intended to complement a student's thesis or dissertation research. The course will focus on a selection of emerging machine learning algorithms and analyze contemporary publications on these techniques. The emphasis will be on algorithms suited to large, complex data sets. Both supervised and unsupervised learning methodologies will be discussed. Applications will be drawn from several signal processing disciplines including speech, image and bioengineering applications.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in ENGR 5022, ENGR 5033, and ECE 8527.

ECE 8529. Fundamentals of EEG Processing. 3 Credit Hours.
Electroencephalography (EEG) records electrical activity along the scalp, measuring spontaneous electrical activity of the brain. The signals measured along the scalp can be correlated with brain activity, which makes it a primary tool for diagnosis of brain-related illnesses. EEG specialists review these waveforms and develop a diagnosis. EEGs traditionally have been used to diagnose epilepsy and strokes. Other common clinical uses have been for diagnoses of coma, encephalopathies, brain death and sleep disorders. EEGs are increasingly being used to diagnose head-related trauma injuries and Alzheimer's disease. Hence, there is a growing need for expertise to interpret EEGs and, equally important, to understand how these conditions manifest themselves in the EEG signal. In this course we will discuss the techniques neurologists use to manually interpret EEGs. A vast archive of clinical EEG recordings will be studied. Since EEG signals are very low-level electrical signals, we will then discuss digital signal processing that is used to convert the raw electrical signals into visualizations that can be readily interpreted. We will also introduce machine learning techniques that are used to automatically interpret and transcribe these signals.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

ECE 8622. Advanced Computer Architecture. 3 Credit Hours.
Advanced course in the design and analysis of computer architecture. Topics will include instruction level parallelism, digital signal processors, network processors and multi-microprocessors. Projects will focus on the design, design analysis and FPGA implementations of computing systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in ECE 5322.

ECE 8712. Power Systems Operation and Control. 3 Credit Hours.
The emphasis of this course is on computational issues that arise in the analysis and solution of the large-scale operations and control problems in actual power systems. Topics include power flow analysis, contingency analysis, security analysis, load forecasting, economic dispatch, unit commitment, optimal power flow, state estimation, and bad data detection, etc. Additional topics for real time control of power system include substation automation, EMS system architecture, distribution management system (DMS), RTU's and PMU's, and situational awareness and visualization.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in ECE 5712.

ECE 8722. Applications of Advanced Power Electronics Technologies. 3 Credit Hours.
In this course, we will start from the basic components and operation principle of power electronic converters and their advanced applications in modern power systems. In particular, the following topics will be included: converter topologies used for grid applications, converter control approaches, AC and DC microgrids, converter interfaced energy storage systems, smart inverters in distribution automation, etc. Applications of power electronic devices and systems used in modern power systems will be presented.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in ECE 5722.

ECE 8742. Power System Stability. 3 Credit Hours.
This course introduces advanced concepts on stability and control of power systems. State space concepts of stability and control of dynamic systems are reviewed. Mathematical models of synchronous and induction machines are developed using Park's transformation. The method is extended to modeling converters, inverters, multimachine power grid, and AC/DC microgrid. Power system stability concept is introduced starting with the swing equation and extended to the analysis of multimachine systems. Advanced control methods of induction motors using vector control are discussed. The course includes extensive Matlab simulation studies of power grid and its components.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B in ECE 5412 and ECE 5712.

ECE 9182. Independent Study I. 3 Credit Hours.
Special study in a particular aspect of engineering under the direct supervision of a graduate faculty member. May be taken once by MS/MSE students and once by Ph.D. students.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 9282. Independent Study II. 3 Credit Hours.
Special study in a particular aspect of engineering under the direct supervision of a graduate faculty member. May be taken once by Ph.D. students.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 9324. VLSI Physical Design. 3 Credit Hours.
This course provides a comprehensive background in the principles and algorithms of VLSI physical design. The algorithms are presented in an intuitive manner so that the student can concentrate on the basic idea of the algorithms. The students are provided enough details to implement the algorithms.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in ECE 8324 and ECE 5324.

ECE 9412. Nonlinear Control System. 3 Credit Hours.
Modeling of nonlinear systems, types of nonlinearity; Phase Plane Analysis, construction of phase portrait, limit cycle, saddle point; Existence and uniqueness of solutions, sensitivity; Lyapunov Stability, region of attraction, construction of Lyapunov functions; Perturbation Analysis variation of parameters, Method of averaging, Describing Functions, frequency domain analysis; Sliding Mode Control, sliding surface; Feedback Linearization, Lie algebra, state and output linearization, applications.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in ECE 8412.

ECE 9512. Detection, Estimation, and Modulation Theory. 3 Credit Hours.
Signal detection and estimation in white and non-white noise, MAP estimation, applications in data and telecommunications. Wiener and Kalman-Bucy filters, linear and non-linear modulation.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in ENGR 5033.

ECE 9514. Adaptive Signal Processing. 3 Credit Hours.
Adaptive filter techniques such as Weiner filter, Linear Prediction, Least-Mean-Square, Recursive Least-Squares, Kalman Filtering algorithms. Introduction to the application of adaptive filters to communications, control, and speech processing.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in (ECE 5514 and ECE 8514)

ECE 9524. Digital Image Processing. 3 Credit Hours.
P2D digital filters, digital image edge detection and segmentation, feature extraction, deblurring, wavelet transforms, JPEG image compression, Fourier optics.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in ECE 8514.

ECE 9622. Parallel Processing Architectures. 3 Credit Hours.
This course provides an in-depth study of the design, engineering, and evaluation of modern parallel computers. Design issues covered include: naming, replication, synchronization, latency, overhead, and bandwidth. Other topics include scalable multiprocessors and interconnection network design.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in ECE 8612.

ECE 9991. Directed Research. 1 to 6 Credit Hour.
Under the guidance of a faculty member, students will select a topic in electro-technology to be researched using at least five references. An extensive research paper must be submitted which will be reviewed by two faculty members. The project report must also be presented at an open seminar. Projects related to industrial applications are encouraged. For non-thesis students only.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 9994. Preliminary Examination Preparation. 1 to 6 Credit Hour.
This course is intended for Ph.D. students who have completed their coursework but who have not yet passed both the Ph.D. Preliminary Examination.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 9995. Project. 1 to 3 Credit Hour.
Under the guidance of a faculty member, students will select a topic in electro-technology to be researched using at least five references. Student present the research at an open seminar, and submits an extensive research paper, which will be reviewed by two faculty members. Projects related to industrial applications are encouraged. For non-thesis students only.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 9996. Thesis. 1 to 3 Credit Hour.
Under the guidance of a faculty member, students will select a topic in electro-technology, and conduct research leading to submission and oral presentation of a thesis proposal and the final defense of the thesis. For thesis students only.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 9998. Pre-Dissertation Research. 1 to 6 Credit Hour.
This course is intended for Ph.D. students who have passed both the Preliminary and Qualifying Examinations but who have not been elevated to candidacy.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

ECE 9999. Dissertation Research. 1 to 6 Credit Hour.
This course is intended only for those students who have achieved Ph.D. Candidacy status. A minimum of 6 semester hours is required for graduation.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.
Student Attribute Restrictions: Must be enrolled in one of the following Student Attributes: Dissertation Writing Student.

Repeatability: This course may be repeated for additional credit.