Electrical Engineering (ECE)

Course information contained within the Bulletin is accurate at the time of publication in June 2025 but is subject to change. For the most up-to-date course information, please refer to the Course Catalog.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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

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

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.

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.

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.

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.

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.

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.
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.

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.

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.

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.

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.

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.

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.

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.

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.

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

ECE 8554. Array Signal Processing. 3 Credit Hours.
This course provides a comprehensive introduction to signal processing techniques using sensor arrays and their key applications in wireless communications and radar systems. In particular, this course covers the following topics: array signal model; direction-of-arrival estimation; sparse array design; sparsity-based array processing; phased array; adaptive beamforming; multiple-input multiple output (MIMO) systems for communications; and MIMO radar.

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

Pre-requisites: Minimum grade of C- in ECE 5514 and ECE 5022.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

Repeatability: This course may be repeated for additional credit.