ESE

Electrical Engineering

ESE 500: Introduction to Engineering Education

This graduate course provides an in-depth examination of engineering knowledge and practices in the context of secondary science content and instruction. The focus is on engineering design principles and how they may be applied to biology, chemistry, and physics disciplinary domains. Key concepts of effective engineering education will be introduced: design-based approaches, optimization, STEM integration, assessment, and transfer of science principles to technology solutions. Students will participate in engineering education opportunities through project design, research, and/or curriculum opportunities at the secondary and post-secondary levels.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 501: System Specification and Modeling

A comprehensive introduction to the field of System-on-Chip design. Introduces basic concepts of digital system modeling and simulation methodologies. Various types of hardware description language (HDL) will be studied, including Verilog, VHDL, and SystemC. Topics include top-down and bottom-up design methodology, specification language syntax and semantics, RTL, behavioral and system-level modeling, and IP core development. Included are three projects on hardware modeling and simulation.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 502: Linear Systems

Development of transfer matrices and state-space equations from the concepts of linearity, time-invariance, causality, and lumpedness. Op-amp circuit implementations. Solutions and equivalent state equations. Companion and modal forms. Stability and Lyapunov equations. Controllability, observability, and their applications in minimal realization, state feedback, and state estimators. Coprime fraction of transfer functions and their designs in pole-placement and model matching. Both the continuous-time and discrete-time systems will be studied.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 503: Stochastic Systems

Basic probability concepts and application. Probabilistic bounds, characteristic functions, and multivariate distributions. Central limit theorem, normal random variables, stochastic processes in communications, control, and other signal processing systems. Stationarity, ergodicity, correlation functions, spectral densities, and transmission properties. Optimum linear filtering, estimation, and prediction.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 504: Performance Evaluation of Communications and Computer Systems

Advanced scheduling theory, queuing models and algorithms for communication and computer systems. Transient analysis and M/G/1 queue models. Networks of queues, mean value analysis and convolution algorithms. Petri networks. Bursty and self-similar traffic. Divisible load theory for scheduling and parallel computer performance evaluation. Prerequisite: ESE 503 or permission of instructor.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 505: Wireless Communications

This course covers first year graduate level material in the area of wireless communications: Wireless channels, overview of digital communications and signal processing for wireless comm., voice and data applications, design basics for wireless modems, analysis of system issues like resource management and handoff, cellular and wireless LAN systems.

Fall or Spring, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 506: Wireless Network

This course will examine the area of wireless networking and mobile computing, looking at the unique network protocol challenges and opportunities presented by wireless communications and host or router mobility. The course will give a brief overview of fundamental concepts in mobile wireless systems and mobile computing, it will then cover system and standards issues including second generation circuit switched and third generation packet switched networks, wireless LANs, mobile IP, ad-hoc networks, sensor networks, as well as issues associated with small handheld portable devices and new applications that can exploit mobility and location information. This is followed by several topical studies around recent research publications in mobile computing and wireless networking field. This course will make the system architecture and applications accessible to the electrical engineer. Prerequisites: ESE 505 and ESE 546 or ESE 548, or permission of instructor

3 credits, Letter graded (A, A-, B+, etc.)

ESE 507: Advanced Digital System Design and Generation

This course focuses on languages, tools and abstractions for design and implementation of digital systems. Course material is divided roughly into three categories: Limitations and constraints on modern digital systems; Hardware design abstractions, languages, and tools (including the SystemVerilog hardware description language); and new architectures and paradigms for digital design. Coursework will be primarily project and assignment based; there will also be reading and discussion of published papers in these areas. Students should have experience with hardware description languages (VHDL, Verilog, or System Verilog) and software (C, C++ or Java).

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 509: Modern Energy Technologies

This course cover a broad array of technologies that are essential to the modern energy industry, specifically focusing on the most contemporary topics and ¿hot¿ areas of research, development, and deployment. Students will gain a quantitative understanding of selected energy generation technologies, energy storage technologies, and pollution control technologies.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 510: Electronic Circuits

This is a course in the design and analysis of analog circuits, both discrete and integrated. The first part of the course presents basic topics related to circuit analysis: laws, theorems, circuit elements and transforms. Fundamental semiconductor devices are introduced next. A number of aspects of circuit design beginning with basic device operation through the design of large analog functional blocks including amplifiers, oscillators and filters are discussed.

Cannot be used to fulfill any ESE degree requirements.
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 511: Solid-State Electronics

A study of the electron and hole processes in solids leading to the analysis and design of solid-state electronic devices. Solutions to the Schrodinger representation of quantum effects, perturbation techniques. Simple band structure, effective mass theorem. Derivation and application of the Boltzmann transport theory. Electrical and thermal conductivities of metals and of semiconductors, and their application to electronic devices. Properties of semi conductors and the theories underlying the characteristics of semiconductor devices.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 512: Introduction to Quantum Systems Engineering

A study of fundamental properties of homojunction and heterojunction semiconductor devices. Derivation of the characteristic equation for p-n junction diodes, for the bipolar junction transistor (BJT) and for the heterojunction bipolar transistor (HBT); the device parameters for low- and high-frequency operation, the effects on the device characteristics of fabrication methods and of structural arrangements. The development of the large-signal and small-signal equivalent circuits for the p-n diode and the BJT and HPT devices, with emphasis on models used in prevalent computer-aided analysis (e.g., SPICE). Consideration of the devices in integrated-circuit applications.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 513: Introduction to Photovoltaics

Introduction to the basic concepts of photovoltaic solar energy conversion, including: 1. The solar resource in the context of global energy demand; 2. The operating principles and theoretical limits of photovoltaic devices; 3. Device fabrication, architecture, and primary challenges and practical limitations for the major technologies and materials used for photovoltaic devices. Students will gain knowledge of the device physics of solar cells, the operating principles of the major commercial photovoltaic technologies, the current challenges and primary areas of research within the field of photovoltaics, and a basic understanding of the role of photovoltaics in the context of the global energy system.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 514: MOSTransistor Modeling

An overview of the metal-oxide semiconductor (MOS) transistor and its models for circuit analysis. The course is modular in structure. In a common first part, CMOS fabrication, device structure and operation are introduced. Starting from basic concepts of electrostatics, MOS field-effect transistor operation is presented in an intuitive fashion, and no advanced background in solid-state theory is required. Analytical models of increasing complexity and their SPICE Implementations are discussed. The second part of the course allows students to focus on their field of preference: Device physics; digital circuits; Analog circuits. The course includes a project in one of these subtopics.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 515: Quantum Electronics I

Physics of microwave and optical lasers. Topics include introduction to laser concepts; quantum theory; classical radiation theory; resonance phenomena in two-level systems; Block equations-Kramers-Kronig relation, density matrix; rate equation and amplification; CO2 lasers; discharge lasers; semiconductor lasers.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 516: Integrated Electronic Devices and Circuits I

Theory and applications: elements of semiconductor electronics, methods of fabrication, bipolar junction transistors, FET, MOS transistors, diodes, capacitors, and resistors. Design techniques for linear digital integrated electronic components and circuits. Discussion of computer-aided design, MSI, and LSI.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 517: Integrated Electronic Devices and Circuits II

Theory and applications: elements of semiconductor electronics, methods of fabrication, bipolar junction transistors, FET, MOS transistors, diodes, capacitors, and resistors. Design techniques for linear digital integrated electronic components and circuits. Discussion of computer-aided design, MSI, and LSI.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 518: Advanced design of low noise and low power analog circuits

Students will learn state-of-the-art circuit techniques for low-noise and low-power amplification and processing of signals from sensors. Examples of circuits are low-noise amplifiers, filters, peak directors and discriminators. Applications range from medical, to security, safety, industrial measurements and physics research. As a course project, students will develop part of a front-end circuit from transistor level to physical layout using industry-standard CAD tools, and will participate in the experimental characterization of those similar circuits. At the end of the course the student will own a solid background and the basic instruments to design low-noise and low-power amplifiers and processing circuits.

Offered in Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 519: Semiconductor Lasers and Photodetectors

The course provides an introduction to performance, testing and fabrication techniques for semiconductor lasers and photodetectors. The topics include fundamentals of laser and detector operation, devices band diagram, device characteristics, and testing techniques for analog and digital edge emitting and surface emitting lasers, avalanche and PIN photodetectors. Special attention is given to the design and working characteristics of transmitters and pumping lasers for telecommunication networks.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 520: Applied Electromagnetics

Wave phenomena and their importance in electromagnetic engineering. Harmonic waves. Phase and group velocities. Dispersive and nondispersive propagation. Transmission lines. Maxwell Equations. Uniform plane waves, waveguides, resonators. Scattering matrix theory. Introduction to antenna theory. Electrostatics and magnetostatics as special cases of Maxwell equations.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 522: Fiber Optic Systems

This course covers the essential components of a modern optical fiber communication system: (I) wave propagation in optical fiber waveguides, (II) transmitter design, (III) receiver design, (IV) single wavelength fiber-optic networks, and (V) wavelength division multiplexing networks.

Prerequisite: ESE 319
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 523: Quantum Computing and Applications

This course is an introduction to and survey of the Quantum Computing, an emerging interdisciplinary field of science which has the potential to revolutionize computation over the next ten years, to transform chemistry, medicine, engineering and communications, as well as to change our understanding of physical world. The course will build intuitive approach to quantum computation and algorithms, but also will advance relevant vocabulary and skills for faculties and graduate students in engineering, computing, applied mathematics, chemistry, physics, and related sciences. The key questions of the quantum computing will be introduced. How to describe quantum systems and quantum operations? What is a quantum computer and what are the limits of quantum power? What is the difference between classical and quantum computation? Quantum teleportation? Quantum entanglement and superposition? How to mitigate errors and decoherence and transmit information through noisy channels? What are business applications and engineering challenges of the quantum computers? What are the gains in running quantum vs. classical algorithms? What are the physical principles of the current quantum computers hardware and what are technology requirements for realistic quantum computers?

4 credits, Letter graded (A, A-, B+, etc.)

ESE 524: Microwave Acoustics

Continuum acoustic field equations. Wave equation, boundary conditions, and Pointing vector. Waves in isotropic elastic media: plane-wave modes, reflection and refraction phenomena, bulk-acoustic-wave (BAW) waveguides, surface acoustic waves (SAW). Plane and guided waves in piezoelectric media. BAW transduction and applications: delay-line and resonator structures, the Mason equivalent circuit, monolithic crystal filters, IM CON dispersive delay lines, acoustic microscopes, SAW transduction and applications: the interdigital transducer, band-pass filters, dispersive filters, convolvers, tapped delay lines, resonators.

Prerequisite: ESE 319
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 525: Moden Sensors in Artificial Intelligence Applications

Sensors are devices that convert physical values into electrical signals. This course will provide practical information on diversified subjects related to the operation principles, design and use of various sensors. Established and novel sensor technologies as well as problems of interfacing various sensors with electronics are discussed.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 526: Silicon Technology for VLSI

This course introduces the basic technologies employed to fabricate advanced integrated circuits. These include epitaxy, diffusion, oxidation, chemical vapor deposition, ion implantation lithography and etching. The significance of the variation of these steps is discussed with respect to its effect on device performance. The electrical and geometric design rules are examined together with the integration of these fabrication techniques to reveal the relationship between circuit design and the fabrication process.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 528: Communication Systems

This course provides a general overview of communication theory and addresses fundamental concepts in this field. After a review of signals and systems representations, various continuous and digital modulation schemes are analyzed. Spread spectrum systems and their application to multiuser communications are also addressed. Advanced communication systems are described and general concepts of wide and local area networks are introduced.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 530: Computer-Aided Design

The course presents techniques for analyzing linear and nonlinear dynamic electronic circuits using the computer. Some of the topics covered include network graph theory, generalized nodal and hybrid analysis, companion modeling. Newton's method in n-dimensions and numerical integration.

Prerequisite: B.S. in Electrical Engineering
Spring, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 531: Statistical Learning and Inference

Minimum variance unbiased estimation, Cramer- Rao lower bounds, learning and inference with linear models, maximum likelihood estimation, least squares estimation, Bayesian inference, statistical decision theory, hypothesis testing with deterministic and random signals, composite hypothesis testing, model selection.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 532: Theory of Digital Communication

Optimum receivers, efficient signaling, comparison classes of signaling schemes. Channel capacity theorem, bounds on optimum system performance, encoding for error reduction, and the fading channel. Source coding and some coding algorithms. Prerequisite: ESE 503

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 533: Convex Optimization and Engineering Applications

Introduction to convex optimization and its applications. Convex sets, functions, and basics of convex analysis. Linear and quadratic programs, second-order cone and semidefinite programming, geometric programming. Duality theory and optimality conditions. Unconstrained minimization methods. Interior-point methods. Nondifferentiable problems. Decomposition methods. Applications in engineering fields including statistical signal processing, communications, networking, energy systems, circuit design, and machine learning.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 534: Cyber Physical Systems

As computers and communication bandwidth become ever-faster and ever-cheaper, computing and communication capabilities will be embedded in all types of objects and structures in the physical environment. Applications with enormous societal impact and economic benefit will be created by harnessing these capabilities in time and across space. We refer to systems that bridge the cyber-world of computing and communications with the physical world as cyber physical systems (CPS). This course covers important areas from the research literature on SPS. Three application domains are emphasized: medical devices for health care, smart transportation systems, and smart buildings. Several key cross-cutting principles, independent of the application domain, are also covered, including formal modeling, embedded systems, real-time systems, feedback control and sensor networks. Prerequisite: Background in embedded systems and computer networking is necessary.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 535: Power System Analysis

The course focuses on fundamental analytics of power systems. It will help students understand major problems in power system static, dynamic, and stability analysis, as well as fundamental optimization issues in power system operation. The course covers power system steady-state modeling with emphasis on admittance and impedance matrix, power system dynamics modeling with emphasis on the functional state-space model, power system analytics with emphasis on power flow analysis, eigenvalue analysis, and time-domain transient simulation, as well as fundamental power system operation issues with emphasis on optimal power flow, unit commitment, and power system control. Emphasis is on using applied mathematics and computer-based methods to analyze power system problems.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 536: Switching and Routing in Parallel and Distributed Systems

This course covers various switching and routing issues in parallel and distributed systems. Topics include message switching techniques, design of interconnection networks, permutation, multicast and all-to-all routing in various networking nonblocking, and rearrangable capability analysis and performance modeling.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 537: Mobile Sensing Systems & Applications

This is a graduate course focusing on recent advances and developments in mobile sensing systems and their applications, especially those leveraging modern mobile devices and embedded sensors. Topics include: conventional mote-class sensor networks, participatory sensing leveraging mobile devices, intelligent hardware and Internet-of-Things, location sensing, future information centric networking, and applications in smart homes, buildings, transportation, environment and health/fitness. Student need to read latest literature and write reviews, work on research problems and develop solutions, present their work and write formal reports. The practice of the basic research skills are major components. This course intends to be self-sufficient and prior experiences in programming, mobile devices and embedded systems is a plus.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 538: Nanoelectronics

The major goals and objectives are to provide graduate students with knowledge and understanding of physical background and applications of nanoelectronics. The course will cover electrical and optical properties of materials and nanostructures, fabrication of nanostructures, nanoelectronic devices including resonant-tunneling devices, transistors, and single-electron transfer devices, as well as applications of nanotechnologies in molecular biology and medicine.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 539: Power Electronics and Motor Drives

This course is designed to cover the basic concepts of motor control, motor drive design and power electronics inverters.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

ESE 540: Reliability Theory

Theory of reliability engineering. Mathematical and statistical means of evaluating the reliability of systems of components. Analytical models for systems analysis, lifetime distributions, repairable systems, warranties, preventive maintenance, and inspection. Software reliability and fault tolerant computer systems. Prerequisite: ESE 503 or permission of instructor

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

ESE 541: Digital System Design

The course provides an introduction to digital and computer systems. The course follows a top-down approach to presenting design of computer systems, from the architectural-level to the gate-level. VHDL language is used to illustrate the discussed issues. Topics include design hierarchy and top-down design, introduction to hardware description languages, computer-aided design and digital synthesis, basic building blocks like adders, comparators, multipliers, latches, flip-flops, registers etc, static and dynamic random access memory, data and control buses, fundamental techniques for combinational circuit analysis and design, sequential circuit design procedures, and programmable logic devices. Testing of digital designs is addressed throughout the course. A mini project will complement the course.

Cannot be used to fulfill any ESE degree requirements.
Spring, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 542: Product Design Concept Development and Optimization

This graduate course will concentrate on the design concept development of the product development cycle, from the creative phase of solution development to preliminary concept evaluation and selection. The course will then cover methods for mathematical modeling, computer simulation and optimization. The concept development component of the course will also cover intellectual property and patent issues. The course will not concentrate on the development of any particular class of products, but the focus will be mainly on mechanical and electromechanical devices and systems. As part of the course, each participant will select an appropriate project to practice the application of the material covered in the course and prepare a final report.

Prerequisites: Undergraduate electrical or mechanical engineering and/or science training.
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 543: Mobile Cloud Computing

Introduction to the basic concepts of mobile cloud computing, including 1. The mobile computing technology used in modern smart phones; 2. The cloud computing technologies used in existing data centers; 3. The synergy of mobile and cloud computing and its applications; and 4. Programming on smart phone utilizing data center services. Students will gain knowledge of the fundamental principles of mobile cloud computing, the major technologies that support mobile cloud computing, the current challenges and primary areas of research within the field of mobile cloud computing, and a basic understanding of the role of mobile cloud computing in the context of the everyday living.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 544: Network Security Engineering

An introduction to computer network and telecommunication network security engineering. Special emphasis on building security into hardware and hardware working with software. Topics include encryption, public key cryptography, authentication, intrusion detection, digital rights management, firewalls, trusted computing, encrypted computing, intruders and virus. Some projects.

Fall, alternate years, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 545: Computer Architecture

The course covers uniprocessor and pipelined vector processors. Topics include: hierarchical organization of a computer system; processor design; control design; memory organization and virtual memory; I/O systems; balancing subsystem bandwidths; RISC processors; principles of designing pipelined processors; vector processing on pipelines; examples of pipelined processors. The course involves a system design project using VHDL.

Prerequisite: ESE 218 or equivalent
Spring, 4 credits, Letter graded (A, A-, B+, etc.)

ESE 546: Networking Algorithms and Analysis

An introduction to algorithms and analysis for computer and telecommunication networks. Continuous time and discrete time single queue analysis. Algorithms from public key cryptography, routing, protocol verification, multiple access, error codes, data compression, search.

Prerequisite: ESE 503 or permission of instructor.
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 547: Digital Signal Processing

A basic graduate course in Digital Signal Processing. Sampling and reconstruction of Signals. Review of Z-Transform theory. Signal flow-graphs. Design of FIR and IIR filters. Discrete and fast Fourier transforms. Introduction to adaptive signal processing. Implementation considerations.

Prerequisite: Senior level course in signals and systems
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 548: Computer Networks

Basic theory and technology of computer communications. Introduction to performance evaluation, error codes and routing algorithms. Other topics include Ethernet, wireless networks including LTE and 5G, fiber optic networking, software defined networking, networking on chips, space networks, data centers, grids and clouds, and network security. 3 credits , grading ABCF.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 549: Advanced VLSI System Testing

This course is designed to acquaint students with fault diagnosis of logic circuits. Both combinatorial and sequential circuits are considered. Concepts of faults and fault models are presented. Emphasis is given to test generation, test selection, fault detection, fault location, fault location within a module and fault correction.

Prerequisite: BS in Electrical Engineering
Spring, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 550: Network Management and Planning

This course provides an introduction to telecommunications and computer network management and planning. Network management is concerned with the operation of networks while network planning is concerned with the proper evolution of network installations over time. Network management topics include meeting service requirements, management operations, management interoperability, and specific architectures such as Telecommunications Management Network (TMN), and Simple Network Management Protocol (SNMP). Network planning topics include planning problem modeling, topological planning design, heuristic and formal solution techniques.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 551: Electronics and Radiation Effects

A study of the effects of radiation on electronic circuit operation. Radiation may come from space or man-made sources such as nuclear reactors or CAT scan machines. Coverage includes types of radiation, types of effects on circuits such as SEE (Single Event Effects), designing circuits to mitigate radiation effects and testing of circuits prior to deployment. Applications include electronics for space and for use in nuclear reactors and certain medical imaging machines.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 552: Interconnection Networks

Formation and analysis of interconnect processing elements in parallel computing organization. Topics include: SIMD/MIMD computers, multiprocessors, multicomputers, density, symmetry, representations, and routing algorithms. Topologies being discussed include: Benes, Omega, Banyan, mesh, hypercube, cube-connected cycles, generalized chordal rings, chordal rings, DeBruijn, Moebius graphs, Cayley graphs, and Borel Cayley graphs.

Prerequisite: ESE 545 or equivalent
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 553: A/D and D/A Integrated Data Converters

This is an advanced course on analog integrated circuit design aspects for data converters. Topics include: continuous and discrete-time signals and systems; sampling theorem; ideal ND and D/A converters; specifications and testing of data converters; basic building blocks in data converters: current sources and mirrors, differential gain stages, voltage references, S/H circuits, comparators: Nyquist D/A and ND converters: principles of data conversion and circuit design techniques; oversampling data converters: low-pass and band-pass delta-sigma modulators, decimation and interpolation for delta-sigma data converters. The attending students must be acquainted with principles of transistor operation, function of simple analysis. Familiarity with SPICE is required.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 554: Computational Models for Computer Engineers

This course covers mathematical techniques and models used in the solution of computer engineering problems. The course heavily emphasizes computer engineering application. Topics covered include set theory, relations, functions, graph theory and graph algorithms, and algebraic structures.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 555: Advanced VLSI Systems Design

Techniques of VLSI circuit design in the MOS technology are presented. Topics include MOS transistor theory, CMOS processing technology, MOS digital circuit analysis and design, and various CMOS circuit design techniques. Digital systems are designed and simulated throughout the course using an assortment of VLSI design tools.

Prerequisite: B.S. in Electrical Engineering or Computer Science
Spring, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 556: VLSI Physical and Logic Design Automation

Areas to be covered are Physical Design Automation and Logic Design Automation. Upon completion of this course, students will be able to develop state-of-the art CAD tools and algorithms for VLSI logic and physical design. Tools will address design tasks such as floor planning, module placement and signal routing. Also, automated optimization of combinational and sequential circuits will be contemplated.

Prerequisite: B.S. in Computer Engineering/ Science or Electrical Engineering
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 557: Digital Signal Processing II: Advanced Topics

A number of different topics in digital signal processing will be covered, depending on class and current research interest. Areas to be covered include the following: parametric signal modeling, spectral estimation, multirate processing, advanced FFT and convolution algorithms, adaptive signal processing, multidimensional signal processing, advanced filter design, dedicated signal processing chips, and signal processing for inverse problems. Students will be expected to read and present current research literature.

Prerequisite: ESE 547 or permission of instructor
Spring, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 558: Digital Image Processing I

Covers digital image fundamentals, mathematical preliminaries of two-dimensional systems, image transforms, human perception, color basics, sampling and quantization, compression techniques, image enhancement, image restoration, image reconstruction from projections, and binary image processing.

Prerequisite: B.S. in Engineering or Physical or Mathematical Sciences
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 559: EMI in Power Electronics Converters: Generation, Propagation and Mitigation

This course is designed to cover the basic concepts of electro-magnetic-interference issues in power electronics converters. The course materials will cover basic concepts of EMI measurement, modeling and mitigation, with the focus on conducted EMI in power electronics converters. The course is structured with lectures and a lab session. This course is offered to both senior undergraduate and graduate students. Students cannot get credit for both undergraduate level and graduate level. Undergraduate and graduate students will take exams and quizzes at the same time but with different designed questions.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated 1 times FOR credit.

ESE 561: Theory of Artificial Intelligence

Problem solving by searching, game trees, constraint satisfaction problems, uncertain knowledge and reasoning, probabilistic reasoning, probabilistic reasoning over time, Markov decision processes, partially observable Markov decision processes, reinforcement learning, generalized reinforcement learning.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 562: AI Driven Smart Grids

The course focuses on Artificial Intelligence (AI) applications to power system analysis, planning and operation. Topics include basics of AI and smart grid, data preprocessing, predictive analytics, AI driven static analytics, such as optimal dispatch, state estimation and security assessment, and AI-based dynamical analytics such as transient stability assessment, dynamic model discovery and emergency control. Emerging topics, including transfer learning, data-driven formal methods, learning-based cybersecurity and big data platform, are also discussed. Prerequisite: An undergraduate course in power systems

3 credits, Letter graded (A, A-, B+, etc.)

ESE 563: Fundamentals of Robotics I

This course covers homogenous transformations of coordinates; kinematic and dynamic equations of robots with their associated solutions; control and programming of robots.

Prerequisite: Permission of instructor
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 564: Artificial Intelligence for Robotics

Artifical Intelligence is intelligence demonstrated by machines , unlike the natural intelligence displayed by humans and animals. Research and AI focuses on the development and analysis of algorithms that learn and perform intelligent behavior with minimal human intervention. This course aims to introduce students some basic techniques and algorithms in AI including probabilistic inference, planning and search, localization, tracking and control, and their applications to robotics.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

ESE 565: Parallel Processing Architectures

This course provides a comprehensive introduction to parallel processing. Topics include types of parallelism, classification of parallel computers, functional organizations, interconnection networks, memory organizations, control methods, parallel programming, parallel algorithms, performance enhancement techniques and design examples for SIMD array processors, loosely coupled multiprocessors, and tightly coupled multiprocessors. A brief overview of dataflow and reduction machines will also be given.

Prerequisite: ESE 545 or equivalent
Spring, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 566: Hardware-Software Co-Design of Embedded Systems

This course will present state-of-the-art concepts and techniques for design of embedded systems consisting of hardware and software components. Discussed topics include system specification, architectures for embedded systems, performance modeling and evaluation, system synthesis and validation. The course is complemented by three mini-projects focused on designing and implementing various co-design methods. Prerequisite: ESE 545, ESE 554 and ESE 333 Fall

3 credits, Letter graded (A, A-, B+, etc.)

ESE 568: Computer and Robot Vision

Principles and applications of computer and robot vision are covered. Primary emphasis is on techniques and algorithms for 3D machine vision. The topics include image sensing of 3D scenes, a review of 2D techniques, image segmentation, stereo vision, optical flow, time-varying image analysis, shape from shading, texture, depth from defocus, matching, object recognition, shape representation, interpretation of line drawings, and representation and analysis of 3D range data. The course includes programming projects on industrial applications of robot vision.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 569: Translational Bioinformatics

Advanced technologies have driven rapid increases in the quantities of biomedical data. Translational bioinformatics develops the specified computational and analytic methods to transform these large-scale datasets into biomedical applicable information and knowledge. It is one of major applications of machine learning and data mining. This course introduces large-scale biomedical data resources and management, data processing and modeling, data mining and machine learning approaches in translational bioinformatics, and provides the hands-on projects for students to practice these approaches for real-world biomedical data.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 575: Advanced VLSI Signal Processing Architecture

This course is concerned with advanced aspects of VLSI architecture in digital signal processing and wireless communications. The first phase of the course covers the derivation of both data transformation and control sequencing from a behavioral description of an algorithm. The next phase reviews the general purpose and dedicated processor for signal processing algorithms. This course focuses on low-complexity high-performance algorithm development and evaluation, system architecture modeling, power-performance tradeoff analysis. The emphasis is on the development of application-specific VLSI architectures for current and future generation of wireless digital communication systems. An experimental/research project is required.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 576: Power System Dynamics

The course provides the background for understanding power system dynamics and numerical simulation techniques. Topics include the numerical integration for large-scale power networks, numerical oscillation and its solution, power system component modeling, frequency-dependent transmission network, nonlinear elements, network equivalents, power network stability, and microgrid stability & control. The area of real-time simulation for cyber-physical power infrastructures will also be discussed.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

ESE 577: Deep Learning Algorithms and Software

This course is an introduction to deep learning which uses neural networks to extract layered high-level representations of data in a way that maximizes performance on a given task. Deep learning is behind many recent advances in AI, including Siri's speech recognition, Facebook's tag suggestions and self-driving cars. Topics covered include basic neural networks, convolutional and recurrent network structures, deep unsupervised and reinforcement learning, and applications to problem domains like speech recognition and computer vision. Classes will be a mix of short lectures and tutorials, hands-on problem solving, and project work in groups.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 578: Quantum-Engineered Power Grids

The course focuses on the applications of quantum information science (QIS) to power system analysis, operation and communication. Topics will cover basics of QIS and smart grid, quantum computing, quantum circuits, quantum-enabled power grid steady-state/ transient/stochastic analysis, application of quantum optimization and quantum machine learning in power grids, quantum control, quantum security, quantum Internet. Emphasis of the course is the practical quantum algorithms in power system applications and hands-on experiments on IBM Quantum platform.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 579: Advances Topics in Translational Bioinformatics

This course introduces the current applications of machine learning and data mining techniques in biomedical data science, discusses the latest translational research areas and progresses, and provides the hands-on team projects for graduate students to explore, design and practice their ¿data-driven¿ solutions for the cutting-edge research topics in biomedical data science.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 581: Microprocessor-Based Systems Engineering II

This course is a study of methodologies and techniques for the engineering design of microprocessor-based systems. Emphasis is placed on the design of reliable industrial quality systems. Diagnostic features are included in these designs. Steps in the design cycle are considered. Specifically, requirement definitions, systematic design implementation, testing, debugging, documentation, and maintenance are covered. Laboratory demonstrations of design techniques are included in this course. The students also obtain laboratory experience in the use of microprocessors, the development of systems, circuit emulation, and the use of signature and logic analyzers.

Spring, 4 credits, Letter graded (A, A-, B+, etc.)

ESE 585: Nanoscale Integrated Circuit Design

This course describes high performance and low power integrated circuit (IC) design issues for advanced nanoscale technologies. After a brief review of VLSI design methodologies and current IC trends, fundamental challenges related to the conventional CMOS technologies are described. The shift from logic-centric to interconnect-centric design is emphasized. Primary aspects of an interconnect-centric design flow are described in four phases: (1) general characteristics of on-chip interconnects, (2) on-chip interconnects for data signals, (3) on-chip power generation and distribution, and (4) on-chip clock generation and distribution. Existing design challenges faced by IC industry are investigated for each phase. Tradeoffs among various design criteria such as speed-power-noise-area are highlighted. In the last phase of the course, several post-CMOS devices, emerging circuit styles, and architectures are briefly discussed. At the end of the course, the students will have a thorough understanding of the primary circuit and physical level design challenges with application to industrial IC design. Prerequisites: ESE555 or ESE330 and ESE 355

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 586: Micro Grids

This course will discuss techniques useful for the grid modernization from a unique angle of microgrid design, analysis and operation. It will cover smart inverters, microgrid architectures, distributed energy resources modeling, microgrid hierarchical control, microgrid stability, fault management, resilient microgrids through programmable network, reliable networked microgrids, and cyber security.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

ESE 587: Hardware Architectures for Deep Learning

This course focuses on the design and implementation of specialized digital hardware systems for executing deep learning algorithms. The course is divided into three sections. First, students will study field-programmable gate arrays (FPGAs) and related tools. Second, the course will present an overview of modern deep learning algorithms and applications (e.g., visual object recognition, or speech recognition). Third, students will apply this knowledge to complete a significant design project implementing and optimizing a deep learning algorithm on an FPGA.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 588: Fundamentals of Machine Learning

The fundamentals of machine learning are introduced including learning with parametric models, online learning: stochastic gradient descent family of methods; classification; logistic regression; the naïve Bayes classifier; the nearest neighbor rule; classification trees; boosting methods; sparsity aware learning: concepts and methods; learning in reproducing kernel Hilbert spaces; Bayesian learning; variational approximation, sparse Bayesian learning, relevance vector machines; neural networks and deep learning; the backpropagation algorithm; convolutional neural networks; recurrent neural networks; adversarial training; dimensionality reduction; PCA; ICA; nonlinear dimensionality reduction. Prerequisite: Stochastic processes or permission by instructor

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 589: Learning Systems for Engineering Applications

The course presents the main methods used in automated (machine) learning for engineering applications. The course discusses representation models for learning, extraction of frequent patterns, classification, clustering and application of these techniques for diverse engineering applications, such as Intranet-of-Things, electronic design automation, and healthcare. The covered topics include an overview of learning systems, learning representations i.e. ontologies, regression models, stochastic models and symbolic models, data preparing techniques, different frequent pattern extraction methods, supervised and unsupervised classification, and basic and advanced clustering algorithms. The course is organized as three modules, each module being centered on a specific theme. Students will learn the characteristics of the enumerated topics, and devise and implement software programs for discussed techniques as part of their project work for the course. Student projects will be assessed using standard benchmarks.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

ESE 590: Practical Machine Learning and Artificial Intelligence

The course provides a broad introduction to the state-of-the-art of machine learning methods through lectures and labs, where the lectured summarize the theoretical foundations of the methods. Students work in teams and utilize modern tools to develop a specific application in areas like computer vision, biomedical engineering and social sciences.

3 credits, Letter graded (A, A-, B+, etc.)

ESE 591: Industrial Project in OEMS Engineering

A student carries out a detailed design of an industrial project in OEMS engineering. A comprehensive technical report of the project and an oral presentation are required.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 592: Distributed Computation, Control and Learning Over Networks

Network Science is an interdisciplinary research area, which typically deals with large-scale complex networks. This course covers fundamental problems in distributed computation and control, including consensus and distributed averaging, distributed optimization, discusses the rendezvous problem and formation control, and explores recent development in distributed machine learning over networks.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

ESE 593: High Power RF Engineering

The course starts with an essential review of the properties of low and medium power RF waves and components including transmission lines, waveguides and cavities, and then proceeds to highlight the properties and limitations under high power RF conditions. The principal deleterious effects taking place at high power levels are caused by arcing (a high peak power effect) and the ohmic dissipation in the metal walls (a high average power effect). Exceeding the power handling capacity of the RF components can result in expensive repairs. Methods of mitigating or avoiding these expensive repairs are discussed. Important applications of high power rf are discussed in depth. Finally the students are given an extended project on implementing a particle accelerator using the traditional method of placing cylindrical cavities in tandem and using the longitudinal electric field in the TM010 cavity mode to pump RF power into a particle beam and cause the desired acceleration of the charge particles.

1-3 credits, Letter graded (A, A-, B+, etc.)

ESE 597: Practicum in Engineering - Internship

This course is for part-time and full-time graduate students, relating to their current professional activity. Participation is in private corporations, public agencies or non-profit institutions. Students will be required to have a faculty advisor as well as a contact in the outside organization to participate with them in regular consultations on their project. Students are required to submit a final written final report to both.

The maximum credits which can be accepted towards the M.S. degree is 3 credits.
Fall, Spring, Summer, 1-3 credits, S/U grading
May be repeated for credit.

ESE 599: Research Master's students

Fall and Spring, 1-12 credits, S/U grading
May be repeated for credit.

ESE 610: Seminar in Solid-State Electronics

Current research in solid-state devices and circuits and computer-aided network design.

Fall and Spring, 3 credits, Letter graded (A, A-, B+, etc.)

ESE 670: Topics in Electrical Sciences

Varying topics selected from current research topics. This course is designed to give the necessary flexibility to students and faculty to introduce new material into the curriculum before it has attracted sufficient interest to be made part of the regular course material. Topics include biomedical engineering, circuit theory, controls, electronics circuits, digital systems and electronics, switching theory and sequential machines, digital signal processing, digital communications, computer architecture, networks, systems theory, solid-state electronics, integrated electronics, quantum electronics and lasers, communication theory, wave propagation, integrated optics, optical communications and information processing, instrumentation, and VLSI computer design and processing.

Fall and Spring, 3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

ESE 691: Seminar in Electrical Engineering

This course is designed to expose students to the broadest possible range of the current activities in electrical engineering. Speakers from both on and off campus discuss topics of current interest in electrical engineering.

Fall and Spring, 1 credit, S/U grading
May be repeated for credit.

ESE 697: Ph.D. Practicum in Teaching

The course provides hands-on experience in classroom teaching. Other activities may include preparation and supervison of laboratory experiments, exams, homework assignments and projects. Final report that summarizes the activities and provides a description of the gained experience and a list of recommendations is required. Prerequisite: G5 status and Permission of Graduate Program Director

3 credits, Letter graded (A, A-, B+, etc.)

ESE 698: Practicum in Teaching

This course enables graduate students to gain experience in teaching and interacting with students enrolled in an electrical and computer engineering course. Students enrolled in ESE-698 are expected to perform various teaching duties required by the course instructor, such as attending lectures, providing office hours, holding review/recitation sessions, assisting in lab sections and grading, etc.

Fall, Spring, Summer, 1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

ESE 699: Dissertation Research on Campus

Prerequisite: Advancement to candidacy (G5). Major portion of research must take place on SBU campus, at Cold Spring Harbor, or at the Brookhaven National Lab.

Fall, Spring, and Summer, 1-9 credits, S/U grading
May be repeated for credit.

ESE 700: Dissertation Research off Campus - Domestic

Prerequisite: Must be advanced to candidacy (G5). Major portion of research will take place off-campus, but in the United States and/or U.S. provinces. Please note, Brookhaven National Labs and the Cold Spring Harbor Lab are considered on-campus. All international students must enroll in one of the graduate student insurance plans and should be advised by an International Advisor.

Fall, Spring, 1-9 credits, S/U grading
May be repeated for credit.

ESE 701: Dissertation Research off Campus - International

Prerequisite: Must be advanced to candidacy (G5). Major portion of research will take place outside of the United States and/or U.S. provinces. Domestic students have the option of the health plan and may also enroll in MEDEX. International students who are in their home country are not covered by mandatory health plan and must contact the Insurance Office for the insurance charge to be removed. International students who are not in their home country are charged for the mandatory health insurance. If they are to be covered by another insurance plan they must file a waiver be second week of classes. The charge will only be removed if other plan is deemed comparable.

All international students must received clearance from an International Advisor.
Fall, Spring, 1-9 credits, S/U grading
May be repeated for credit.

ESE 800: FULL TIME SUMMER RESEARCH

May be repeated for credit.