COURSE REQUIREMENTS FOR MSC STUDENTS
The program requires 24 semester hours of graduate-level courses. At least three of these courses must be from the list of “depth” courses in the student’s concentration and at least one must be outside this list; these courses are known as “breadth” courses. None of these courses can be from the list of “excluded courses.” For students in the computer-engineering-related concentrations—computer systems and software; computer networks and security; and computer vision, machine learning, and algorithms—at least 20 semester hours of the 32 required semester hours must be graduate-level ECE courses. For other concentrations, at least 24 semester hours of the 32 required semester hours must be graduate-level ECE courses. More details on MSC requirements can be found in the Graduate Program Guide (http://www.ece.neu.edu/sites/default/files/pdfs/ece/ecgraduateprogramguide-fall_2016.pdf).

COURSE REQUIREMENTS FOR MST STUDENTS
The program requires 24 semester hours of graduate-level courses. At least three of these courses must be from the list of “depth” courses in the student’s concentration and at least one must be outside this list; these courses are known as “breadth” courses. None of these courses can be from the list of “excluded courses.” At least 12 semester hours of the required 24 semester hours must be graduate-level ECE courses. In addition, the program requires 8 semester hours of Thesis (EECE 7990). More details on MST requirements can be found in the Graduate Program Guide (http://www.ece.neu.edu/sites/default/files/pdfs/ece/ecgraduateprogramguide-fall_2016.pdf).

Graduate Certificate Options
Students enrolled in a master’s degree in electrical and computer engineering have the opportunity to also pursue one of the many engineering graduate certificate options in addition to or in combination with the MS degree. Students should consult their faculty advisor regarding these options (http://catalog.northeastern.edu/graduate/engineering/graduate-certificate-programs).

GORDON INSTITUTE OF ENGINEERING LEADERSHIP OPTION
Students have the opportunity to pursue the Master of Science in Electrical and Computer Engineering Leadership (MSECEL) (http://catalog.northeastern.edu/graduate/engineering/electrical-computer-engineering-leadership-msecel) along with the Graduate Certificate in Engineering Leadership.

In addition, students have the opportunity to pursue the Gordon Engineering Leadership Program (http://catalog.northeastern.edu/graduate/engineering/leadership) in combination with the Master of Science in Electrical and Computer Engineering. This option results in an increase in total hours beyond that required for the master’s degree only.

Electrical and Computer Engineering PhD Course Requirements
The student and his or her dissertation committee determine the program of study. A typical program comprises 24 semester hours of course work beyond the Master of Science degree. Students who enter the program with a bachelor’s degree complete the curriculum for a Master of Science degree with an area of concentration. After that, as a minimum, the PhD program must include at least 16 semester hours of graduate course work beyond the Master of Science degree, at least 8 semester hours of which must be graduate-level ECE courses. Students who enter the program with a relevant and approved Master of Science degree complete a minimum of 16 semester hours of graduate course work, at least 8 semester hours of which must be graduate-level ECE courses. All students must achieve a minimum cumulative GPA of 3.000.
Programs

**Doctor of Philosophy (PhD)**
- Computer Engineering (http://catalog.northeastern.edu/graduate/engineering/electrical-computer/computer-engineering-phd)
- Computer Engineering—Advanced Entry (http://catalog.northeastern.edu/graduate/engineering/electrical-computer/computer-engineering-phd-advanced)
- Electrical Engineering (http://catalog.northeastern.edu/graduate/engineering/electrical-computer/electrical-engineering-phd)
- Electrical Engineering—Advanced Entry (http://catalog.northeastern.edu/graduate/engineering/electrical-computer/electrical-engineering-phd-advanced)

**Master of Science (MS)**
- Applied Physics and Engineering (http://catalog.northeastern.edu/graduate/science/interdisciplinary/applied-physics-engineering-ms)
- Data Science (http://catalog.northeastern.edu/graduate/computer-information-science/computer-science/data-science-ms)

**Master of Science in Electrical and Computer Engineering (MSECE)**
- Concentration in Communications, Control, and Signal Processing (http://catalog.northeastern.edu/graduate/engineering/electrical-computer/electrical-computer-engineering-concentration-communications-control-signal-processing-msece)
- Concentration in Computer Systems and Software (http://catalog.northeastern.edu/graduate/engineering/electrical-computer/computer-systems-software)
- Concentration in Computer Networks and Security (http://catalog.northeastern.edu/graduate/engineering/electrical-computer/computer-networks-security)
- Concentration in Computer Vision, Machine Learning, and Algorithms (http://catalog.northeastern.edu/graduate/engineering/electrical-computer/computer-vision-machine-learning-algorithms)
- Concentration in Electromagnetics, Plasma, and Optics (http://catalog.northeastern.edu/graduate/engineering/electrical-computer/electrical-computer-engineering-concentration-electromagnetics-plasma-optics-msece)
- Concentration in Microsystems, Materials, and Devices (http://catalog.northeastern.edu/graduate/engineering/electrical-computer/electrical-computer-engineering-concentration-microsystems-materials-devices-msece)
- Concentration in Power Systems (http://catalog.northeastern.edu/graduate/engineering/electrical-computer/electrical-computer-engineering-concentration-power-systems-msece)

**Master of Science in Electrical and Computer Engineering Leadership (MSECEL)**
- Electrical and Computer Engineering Leadership (http://catalog.northeastern.edu/graduate/engineering/electrical-computer/electrical-computer-engineering-leadership-msecel)

**Courses**

**Electrical and Computer Engineering Courses**

**EECE 5155. Wireless Sensor Networks and the Internet of Things. 4 Hours.**
Covers design and modeling of architectures, communication protocols, and algorithms for wireless sensor networks. The first part of the course covers general aspects of wireless sensor networking, including protocol design, modeling, and simulation at all layers of the communication stack. The second part covers standardization efforts, including Bluetooth, IEEE 802.15.4 and Zigbee, RFID, 6LowPan, and Internet of Things, among others. The third part covers applications of sensor networks technology to many challenging problems of our times, including cyber-physical systems, smart cities, smart transportation systems, and underwater sensing systems.

**EECE 5161. Thin Film Technologies. 4 Hours.**
Covers the fundamentals of vacuum technology, thin film deposition technologies, characterization technologies, their applications in different industries, and the frontiers of research activities on thin film deposition technologies. Thin films are fundamental building blocks for integrated circuits chips, microelectromechanical systems (MEMS) devices, and nanoelectromechanical system devices (NEMS), etc., and play critical roles in determining the performance of IC circuits, MEMS, and NEMS devices. Topics include vacuum technologies; vacuum pumps; vacuum system design and analysis; different thin film deposition technologies, including sputtering, chemical vapor deposition, electrochemical deposition, atomic layer deposition, etc.; and different thin film characterization technologies, in particular the magnetic thin film characterization technologies, including VSM, PPMS, FMR, MOKE, etc. Students who do not meet course prerequisites may seek permission of instructor.

**EECE 5170. Introduction to Multiferroics Materials and Systems. 4 Hours.**
Offered by the NSF Nanosystems Engineering Research Center for Translational Applications of Nanoscale Multiferroic Systems (TANMS), which is co-taught by professors from University of California, Los Angeles; University of California, Berkeley; Cornell University; California State University, Northridge; and Northeastern University. Course lectures are available online for remote students. Topics include introduction to multiferroics; atomic structure of multiferroics (chemistry); multiferroic material science; continuum-level analysis of multiferroic materials; and multiferroic devices.

**EECE 5576. Wireless Communication Systems. 4 Hours.**
Examines fundamental principles of wireless system design, focusing on modern techniques used in cellular systems and wireless local area networks. Covers various levels of system design, from modulation/detection to traffic analysis. Introduces basics of radio propagation and studies their effect on communication signals. Special topics include spatial frequency reuse; call blocking and cellular system capacity; power control and hand-off strategies; channel access and sharing; orthogonal frequency division multiplexing (OFDM—a modulation technique used in WLAN and the fourth-generation [4G] cellular systems) and spread spectrum modulation (third-generation WCDMA systems); diversity techniques and multi-input multi-output (MIMO) signal processing. Requires an undergraduate course in communications systems.

**EECE 5580. Classical Control Systems. 4 Hours.**
Introduces the analysis and design of classical control systems. Examines control system objectives, modeling and mathematical description, transfer function and state-variable representations, feedback control system characteristics, system responses, and stability of feedback systems. Also addresses compensator design based on root-locus and frequency response, and modern control system design using state-variable feedback.
EECE 5581. Lab for EECE 5580. 1 Hour.
Accompanies EECE 5580. Covers the practical aspects of control systems design through lab experiments. Topics vary and include computer simulation, digital computer control, and use of CAD packages such as MATLAB for analysis and design of control systems. Examples emphasize concepts introduced in EECE 5580, such as system response to stimuli, stability, and robustness.

EECE 5606. Micro- and Nanofabrication. 4 Hours.
Provides an overview of integrated circuit fabrication from the viewpoint of a process engineer. Offers students an opportunity to fabricate micro- and nanoscale devices in integrated lab sessions. Focuses on the physics, chemistry, and technology of integrated circuit fabrication in the lecture portion of the course, while students fabricate and test novel devices (an electrohydrodynamic micropump and three-dimensional carbon nanotube interconnects) in integrated lab sessions. Concentrates on silicon IC technology but also includes examples from other materials and device systems including microelectromechanical (MEMS) technologies that are used to build devices such as accelerometers, pressure sensors, and switches for telecommunications and other current examples provided from nanofabrication and nanotechnology. Lab hours are arranged.

EECE 5610. Digital Control Systems. 4 Hours.
Covers sampling and analysis tools for linear discrete-time dynamic systems, including the design of digital control systems using transform techniques by discrete equivalent and direct design methods; root locus, Bode and Nyquist diagrams, and Nichols charts; controller implementation issues, such as digital filter realizations, nonlinear effects due to quantization, round off, dead band, and limit cycles; and selection of the sampling rate.

EECE 5626. Image Processing and Pattern Recognition. 4 Hours.
Introduces processing and analysis of digital images with the goal of recognition of simple pictorial patterns. Topics include discrete signals and systems in 2D, digital images and their properties, image digitization, image enhancement, image restoration, image segmentation, feature extraction, object recognition, and pattern classification principles (Bayes rules, class boundaries) and pattern recognition methods.

EECE 5627. Arithmetic and Circuit Design for Inexact Computing with Nanoscaled CMOS. 4 Hours.
Studies the principles of inexact (approximate) computing through arithmetic and circuit design. By reducing circuit complexity, critical path delay, and power dissipation at the expense of introducing processing errors in computation, inexact computing is one of the leading emerging paradigms in nanoscale computing. Topics include basic computer arithmetic, approximation criteria, error analysis, nanoscale CMOS principles (PTMs), case studies, and experimental assessment.

EECE 5639. Computer Vision. 4 Hours.
Introduces topics such as image formation, segmentation, feature extraction, matching, shape recovery, dynamic scene analysis, and object recognition. Computer vision brings together imaging devices, computers, and sophisticated algorithms to solve problems in industrial inspection, autonomous navigation, human-computer interfaces, medicine, image retrieval from databases, realistic computer graphics rendering, document analysis, and remote sensing. The goal of computer vision is to make useful decisions about real physical objects and scenes based on sensed images. Computer vision is an exciting but disorganized field that builds on very diverse disciplines such as image processing, statistics, pattern recognition, control theory, system identification, physics, geometry, computer graphics, and learning theory. Requires good programming experience in Matlab or C++.

EECE 5640. High-Performance Computing. 4 Hours.
Covers accelerating scientific and other applications on computer clusters, many-core processors, and graphical processing units (GPUs). Modern computers take advantage of multiple threads and multiple cores to accelerate scientific and engineering applications. Topics covered include parallel computer architecture, parallel programming models, and theories of computation, as well as models for many-core processing. Highlights implementation of computer arithmetic and how it varies on different computer architectures. Includes an individual project where each student is expected to implement an application, port that application to several different styles of parallelism, and compare the results. Programming is done in variants of the C programming language.

EECE 5642. Data Visualization. 4 Hours.
Introduces relevant topics and concepts in visualization, including computer graphics, visual data representation, physical and human vision models, numerical representation of knowledge and concept, animation techniques, pattern analysis, and computational methods. Topics include tools and techniques for practical visualization and elements of related fields, including computer graphics, human perception, computer vision, imaging science, multimedia, human-computer interaction, computational science, and information theory. Covers examples from a variety of scientific, medical, interactive multimedia, and artistic applications. Includes hands-on exercises and projects. Emphasizes modern engineering applications of computer vision, graphics, and pattern classification methodologies for data visualization.

EECE 5643. Simulation and Performance Evaluation. 4 Hours.
Studies simulation and performance evaluation in computer systems. Primarily covers both classic and timely techniques in the area of performance evaluation, including capacity planning to predict system performance, scheduling, and resource allocation in computer systems. Introduces basic computational and mathematical techniques for modeling, simulating, and analyzing the performance by using simulation, including models, random-number generation, statistics, and discrete event-driven simulation.

EECE 5644. Introduction to Machine Learning and Pattern Recognition. 4 Hours.
Studies machine learning, the study and design of algorithms that enable computers/machines to learn from experience/data. Covers a range of algorithms, focusing on the underlying models between each approach. Emphasizes the foundations to prepare students for research in machine learning. Topics include Bayes decision theory, maximum likelihood parameter estimation, model selection, mixture density estimation, support vector machines, neural networks, probabilistic graphics models, and ensemble methods (boosting and bagging). Offers students an opportunity to learn where and how to apply machine learning algorithms and why they work.

EECE 5647. Nanophotonics. 4 Hours.
Introduces basic concepts and recent developments in nanophotonic materials and devices. Nanophotonics is one very important research area in nanotechnology. Discusses the fundamentals of electromagnetics (Maxwell’s equations, polarization, wave propagations, etc.); quantum mechanics; and typical nanofabrication and characterization techniques. Focuses on specific topics in nanophotonics, including silicon photonics; photonic crystals; plasmonics and optical metamaterials, with their diverse applications in optical circuits; imaging; optical trapping; biomedical sensing; and energy harvesting. Offers students an opportunity to obtain a fundamental understanding of the property and manipulation of light at the nanoscale.
EECE 5648. Biomedical Optics. 4 Hours.
Covers biomedical optics and discusses the theory and practice of biological and medical applications of lasers. Topics covered include fundamentals of light propagation in biological tissues, light-matter interactions such as elastic and inelastic scattering, fluorescence and phosphorescence; diagnostic imaging techniques such as confocal fluorescence microscopy, diffuse optical tomography, and optical coherence tomography; and therapeutic interventional techniques, including photodynamic therapy, laser thermal therapies, and fluorescence-guided surgeries.

EECE 5649. Design of Analog Integrated Circuits with Complementary Metal-Oxide-Semiconductor Technology. 4 Hours.
Covers theoretical analysis, practical design, and simulation of analog integrated circuits implemented in complementary metal-oxide-semiconductor (CMOS) fabrication process technologies. Introduces cadence tools for circuit simulations, physical layout, and layout verification. Begins with basic concepts such as CMOS device models, DC and small-signal analysis techniques for single- and multistage amplifiers, biasing configurations, and reference generation circuits. Explores differential signal processing, operational amplifiers, operational transconductance amplifiers, and common-mode feedback circuits. Analysis methods include the evaluation of linearity, noise, stability, and device mismatches from process variations. Addresses some advanced design techniques, such as linearity improvement methods, frequency compensation, and digitally assisted performance tuning.

EECE 5664. Biomedical Signal Processing. 4 Hours.
Introduces biomedical signal processing and biomedical imaging and image processing. Specific topics covered depend on instructor and/or student's areas of interest and are drawn from a variety of application areas. They include the nature and processing of intrinsic signals such as cardiac and neurological bioelectric signals, natural processing of external signals such as auditory and visual processing, and topics related to a variety of medical and biological imaging modalities.

EECE 5666. Digital Signal Processing. 4 Hours.
Presents the theory and practice of modern signal processing techniques. Topics include the characteristics of discrete signals and systems, sampling, and A/D conversion, the Z-transform, the Fourier transform, and the discrete Fourier transform; fast Fourier transform algorithms; design techniques for IIR and FIR digital filters; multirate digital filters; and quantization effects in digital signal processing. Graduate students may register for this course only if they did not complete an undergraduate course in digital signal processing; such graduate registration requires approval of instructor and an internal departmental petition.

EECE 5667. Lab for EECE 5666. 1 Hour.
Accompanies EECE 5666. Focuses on practical aspects of DSP by programming a digital signal processing chip in a high-level language using an integrated development and debugging environment. Topics include input/output operations via A/D and D/A converters, digital frequency synthesis, computation of discrete-time convolution, and design and implementation of both FIR and IIR filters.

EECE 5680. Electric Drives. 4 Hours.
Examines all subsystems that comprise an electric drive including electric machines, power electronic converters, mechanical system requirements, feedback controller design, and interactions with utility systems. Based on an integrative approach that requires minimal prerequisites: a junior-level course in signals and systems and some knowledge of electromagnetic field theory (possibly from physics classes), and does not require separate courses in electric machines, controls, or power electronics.

EECE 5681. Lab for EECE 5680. 0 Hours.
Accompanies EECE 5680. Covers topics from the course through various experiments.

EECE 5682. Power Systems Analysis 1. 4 Hours.
Covers fundamentals including phasors, single-phase and balanced three-phase circuits, complex power, and network equations; symmetrical components and sequence networks; power transformers, their equivalent circuits, per unit notation, and the sequence models; transmission line parameters including resistance, inductance, and capacitance for various configurations; steady-state operation of transmission lines including line loadability and reactive compensation techniques; power flow studies including Gauss-Speidel and Newton Raphson interactive schemes; symmetrical faults including formation of the bus impedance matrix; and unsymmetrical faults including line-to-ground, line-to-line, and double line-to-ground faults.

EECE 5683. Power Systems Lab. 1 Hour.
Accompanies EECE 5682. Addresses topics such as transmission line constants, load flow and short-circuit studies, and transient stability. Includes upgrading the design of a small power system.

EECE 5684. Power Electronics. 4 Hours.
Provides tools and techniques needed to analyze and design power conversion circuits that contain switches. The first part of the course emphasizes understanding and modeling of such circuits, and provides a background for engineering evaluation of power converters. The second part covers dynamics and control of this class of systems, enabling students to design controllers for a variety of power converters and motion control systems. Addresses a set of analytical and practical problems, with emphasis on a rigorous theoretical treatment of relevant questions. Designed for students with primary interests in power conditioning, control applications, and electronic circuits, but it could prove useful for designers of high-performance computers, robots, and other electronic and electromechanical (mechatronic) systems in which the dynamical properties of power supplies become important.

EECE 5685. Lab for EECE 5684. 0 Hours.
Accompanies EECE 5684. Covers topics from the course through various experiments.

EECE 5686. Electrical Machines. 4 Hours.
Reviews phasor diagrams and three-phase circuits; the magnetic aspects including magnetic circuits and permanent magnets; transformers, their equivalent circuits, and performance; principles of electromechanical energy conversion; elementary concepts of rotating machines including rotating magnetic fields; and steady-state theory and performance of induction machines, synchronous machines, and direct current machines.

EECE 5688. Analysis of Unbalanced Power Grids. 4 Hours.
Examines common types of power system faults. Starts with a detailed description of three-phase modeling of basic power system elements such as transmission lines, transformers, and generators. Then presents fundamentals of three-phase circuit analysis in the steady state, both for balanced and unbalanced operating conditions. Uses symmetrical component transformation and positive, negative, and zero sequence networks to analyze unbalanced systems. Presents methods to calculate fault currents and postfault bus voltages. Reviews basic protective relaying and relay settings using typical distribution system examples.
EECE 5694. Electromagnetic Photonic Devices. 4 Hours.
Introduces basic principles of photonic devices. Topics include crystal optics, dielectric optical waveguides, waveguide couplers, electro-optic devices, magneto-optic devices, acousto-optic devices, nonlinear effects, and optical switching. Discusses both theory and concept. This is a multidisciplinary course, and novel emerging areas in nanoscale optics and metamaterials are described.

EECE 5695. Radio-Frequency and Optical Antennas. 4 Hours.
Introduces the fundamental physical principles for electromagnetic radiation from antennas. Presents the most important mathematical techniques for radiation analysis. Applies these principles and techniques to practical antenna systems. Starts with the fundamental parameters of the antennas. Introduces the vector potentials and the theorems that are needed for the derivation of the radiation integrals from Maxwell’s equations. Covers the application of these theories to practical antennas in radio frequency and optical communication systems and in new emerging areas. Some examples are wire antennas, loop antennas, linear and two-dimensional planer phrased arrays, patch antennas, frequency-independent antennas, and aperture and reflector antennas. Also discusses metamaterial nanoscale optical antennas.

EECE 5696. Energy Harvesting Systems. 4 Hours.
Covers different aspects of energy harvesting systems, such as energy harvesting devices, power conditioning, energy storage, etc. Explores different energy harvesting technologies, including solar energy, wind energy, vibration energy, thermoelectric energy, etc. Examines different kinds of functional materials used for different energy harvesting technologies, including piezoelectric materials, magnetic materials, solar cell materials, thermoelectric materials, etc. Emphasizes vibration energy harvesting technologies and functional materials for vibration energy harvesting.

EECE 5697. Acoustics and Sensing. 4 Hours.
Introduces the fundamental concepts of acoustics and sensing with waves. Offers a unified theoretical approach to the physics of image formation through scattering and wave propagation in sensing. Topics include the linear and nonlinear acoustic wave equation; sources of sound; reflection, refraction, transmission, and absorption; bearing and range estimation by sensor array processing, beam forming, matched filtering, and focusing; diffraction, bandwidth, ambient noise, and reverberation limitations; scattering from surfaces, volumes, and objects by Green’s theorem; forward scatter, shadows, Babinet’s principle, extinction, and attenuation; ray tracing and waveguides in remote sensing; and applications to acoustic, radar, seismic, thermal, and optical and sensing exploration.

EECE 5698. Special Topics in Electrical and Computer Engineering. 4 Hours.
Covers special topics in electrical and computer engineering. Topics are selected by the instructor and vary from semester to semester. May be repeated up to four times.

EECE 6000. Introduction to Cooperative Education. 1 Hour.
Designed to introduce graduate engineering students to the cooperative education program and focuses on skills that provide a basis for successful co-op engagement. Affords students the opportunity to develop job-search, job-survival, and career-management skills. Seeks to help students understand the co-op program, policies, and expectations; understand how to use the Northeastern Web site to access online information used in the job-search process; identify and describe their skills and work values and how they relate to their career choices; learn how to write and critique a resume; learn and practice proper interviewing skills and techniques; and communicate their interests, skills, needs, and future plans to their co-op coordinator and future employers.

EECE 6960. Exam Preparation—Master’s. 0 Hours.
Offers the student the opportunity to prepare for the master’s qualifying exam under faculty supervision.

EECE 6962. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

EECE 6964. Co-op Work Experience. 0 Hours.
Provides eligible students with an opportunity for work experience. May be repeated without limit.

EECE 6965. Co-op Work Experience Abroad. 0 Hours.
Provides eligible students with an opportunity for work experience abroad. May be repeated without limit.

EECE 6966. Practicum. 1-4 Hours.
Provides eligible students with an opportunity for practical experience. May be repeated without limit.

EECE 7105. Optics for Engineers. 4 Hours.
Provides an introductory graduate course in optics, presenting the engineering concepts necessary to understand and evaluate electro-optical systems. Begins with a brief but rigorous treatment of geometric optics, including matrix methods, aberrations, and pupils and windows, with practical examples of optical instruments and electro-optical systems. Topics include polarization, interference, diffraction, and optical properties of crystals, thin films, optical resonators, guided waves, modulators, and detectors. Presents concepts with examples from modern optical systems such as LiDAR, fiber-optical sensors, range finders, infrared systems, and optical communication systems. Requires a Bachelor of science in engineering or physics.

EECE 7200. Linear Systems Analysis. 4 Hours.
Covers fundamental algebraic concepts and algebraic structures. Topics include linear operators and their representations; matrices, algebraic equations, equivalence, and similarity transformations; introduction to the state-variable theory of continuous and discrete linear systems; standard canonical representations, the concept of state, and the representation of interconnected systems, linear spaces, the state equations, and their solution; stability, and introduction to the general control problem in terms of controllability and observability.

EECE 7201. Solid State Devices. 4 Hours.
Covers the fundamental elements of solid-state device physics and the application of these principles. Seeks to provide students with the opportunity to develop an understanding of pn junctions, bipolar junction transistors, and MOSFETs.

EECE 7202. Electromagnetic Theory 1. 4 Hours.
Examines the fundamental equations, their physical meaning, principal mathematical techniques, and important engineering applications. Topics include sources of the electromagnetic field, Lorentz force equation, integral form of Maxwell’s equations and point relations (differential equations and boundary conditions), electromagnetic energy and power, propagation of uniform and nonuniform plane waves in homogeneous media, reflection and refraction, scalar and vector potentials, solutions in the absence of boundaries for static and dynamic problems, solutions to boundary value problems, duality, uniqueness, images, physical theory of diffraction, and general theory of metal and dielectric wave-guides and resonators for Cartesian and cylindrical systems.
EECE 7203. Complex Variable Theory and Differential Equations. 4 Hours.

EECE 7204. Applied Probability and Stochastic Processes. 4 Hours.
Covers fundamentals of probability and stochastic processes with applications to estimation and queuing theory. Includes basic laws of probability, conditioning, and Bayes rule. Topics include random variables and their functions; PDF, PMF, and CDF notions; statistical averages; moments and characteristic functions; multiple random variables; joint and conditional PDF and PMF; multiple functions of random variables; correlation and covariance; mean squared estimation of random variables; Markov, Chebyshev, and Chernov inequalities; various notions of convergence of random variable sequences; laws of large numbers; central limit theorem; and large deviation theory. As time permits, discusses basic notions of estimation and properties of estimators, unbiased and minimum variance estimation, CRLB, sufficient statistics, consistency of estimators, basic notions of discrete and continuous-time random processes, mean and autocorrelation function, WSS and cyclo-stationary processes, ergodicity of random processes, and other topics. Requires a strong understanding of linear systems, transform techniques, and linear algebra.

EECE 7205. Fundamentals of Computer Engineering. 4 Hours.
Introduces fundamental techniques in computer engineering used throughout the graduate curriculum. Covers basic programming and analysis methods and the formulation and solution of a wide range of computer engineering problems. Also discusses the applications of algorithm analysis and complexity theory to analyzing and solving problems. Emphasizes those fundamental computational problems and related algorithms whose solution can be obtained in polynomial time. For basic computational problems such as sorting, searching, elementary graph algorithms, shortest-paths problems, as well as flow problems in networks, many different algorithms and data structures are described and analyzed, implemented, and compared both from a theoretical and from an experimental point of view.

EECE 7211. Nonlinear Control. 4 Hours.
Discusses phase plane analysis for nonlinear systems. Topics include fundamentals of Lyapunov theory; absolute stability, passivity, averaging, singular perturbation, input-output stability, and other advanced stability topics; describing functions; nonlinear control methods based on linearization, feedback linearization, sliding control, Lyapunov, and passivity and center manifold theory and bifurcations.

EECE 7212. Multivariable Control Systems. 4 Hours.
Discusses mathematical preliminaries, polynomial, and polynomial matrices; representations of linear multivariable system; matrix fraction description (MFD) and polynomial matrix description (PMD); responses of linear multivariable systems; controllability, observability, and canonical forms; poles and zeros of multivariable systems; stability; realization problem; interaction control; state feedback and observer design; compensator design, stability, and robustness; noninteraction control; and frequency domain design techniques.

EECE 7213. System Identification and Adaptive Control. 4 Hours.
Discusses fundamental issues of adaptive identification and control, such as stability of adaptive systems, convergence, persistent excitation, and robustness. Identification is the process of mathematically modeling a system based on measurement data that may be limited or uncertain. Adaptive control, then, is the means by which a system that is poorly modeled is controlled adequately. Enhances the underlying basic ideas that are essential for adaptive control. Emphasizes recursive approaches, such as recursive least squares algorithm, where parameter estimates are updated in real time. Covers simple adaptive systems, adaptive observers, and adaptive control. Discusses in detail two major adaptive schemes, model reference adaptive control (MRAC) and self-tuning regulators (STR).

EECE 7214. Optimal and Robust Control. 4 Hours.
Explores state-space, time-domain techniques for analyzing and designing optimal and robust linear control systems. Introduces basic concepts of dynamic optimization and applies them to problems of short-term and long-term optimal control, path planning and stabilization, state estimation, and filtering. Emphasizes linear quadratic optimization, H2 control, H-infinity control, and mu-synthesis. Reviews pertinent linear systems concepts and discusses connections with a geometric intuition relating quadratic optimization to projections.

EECE 7220. Power System Analysis 2. 4 Hours.
Continues EECE 5682. Reviews power flow studies, power system protection, power system controls, transient operation of transmission lines, transient stability, and HVDC transmission.

EECE 7221. Power System Operation and Control. 4 Hours.
Provides tools and techniques needed to analyze and quantify phenomena that arise in operation and control of modern power systems. Considers problems that have a wide-ranging importance in power systems and includes analysis of steady-state and control of power systems dynamics. These problem areas share a common mathematical framework. The first part of the course covers a classical study of steady states in power systems and the solution of voltage stability problems associated with them. The goal is to present problems (and solutions) of load flow with several modifications, namely, frequency deviations and voltage-sensitive loads. The second part covers modeling, analysis, and controller design for electromechanical transients in power systems (load variations, frequency, and power transmission dynamics). Connections are established with modern robust control theory. Requires a knowledge of controls.

EECE 7222. Power Systems State Estimation. 4 Hours.
Offering an up-to-date account of the strategies utilized in state estimation of electric power systems. Provides a broad overview of power system operation and the role of state estimation in overall energy management. Presents an abundance of examples, models, tables, and guidelines to clearly examine new aspects of state estimation, the testing of network observability, and methods to assure computational efficiency.

EECE 7226. Modeling and Simulation of Power System Transients. 4 Hours.
Provides computer modeling of linear and nonlinear power system components to be used in transient studies. Covers methods of digital simulation of power systems operating in the steady-state and transient conditions. Discusses use of transient simulation programs for design and analysis of power systems. Students are asked to carry out a term project and deliver a presentation about its outcome.
EECE 7228. Advanced Power Electronics. 4 Hours.
Designed to familiarize students with advanced power electronic circuits. Covers single-phase and three-phase rectifiers and inverters, including their principles of the operation, design, analysis, and applications. Diode rectifiers, phase-controlled rectifiers, and switch mode rectifiers and inverters are among the topics. Introduces different modulation techniques. If time permits, covers three-phase ac-ac converters and soft switching techniques, as well.

EECE 7236. Special Topics in Control. 4 Hours.
Covers aspects of controls not studied in other courses. Topics may vary from year to year. May be repeated without limit.

EECE 7237. Special Topics in Power Electronics. 4 Hours.
Covers aspects of power electronics not studied in other courses. Topics may vary from year to year. May be repeated without limit.

EECE 7238. Special Topics in Electric Drives. 4 Hours.
Covers aspects of electric drives not studied in other courses. Topics may vary from year to year. May be repeated without limit.

EECE 7239. Special Topics in Power Systems. 4 Hours.
Covers aspects of power systems not studied in other courses. Topics may vary from year to year. May be repeated without limit.

EECE 7240. Analog Integrated Circuit Design. 4 Hours.
Treats the analysis and design of analog ICs, their functional performance, and applications. Focuses on the various building blocks of analog circuits, their operation, and the underlying principles and techniques, with analysis supplemented by CAD simulation. Topics include modeling and layout of CMOS, bipolar, BiCMOS devices, and passive components; DC building blocks, including precision current and voltage references; performance analysis of signal gain, impedances, and frequency response and speed of basic/compound amplifier structures; architectures of operational amplifiers, including low-voltage, OTAs, and three-stage designs; feedback and performance merits, topologies, instability, and frequency compensation of feedback amplifiers; nonlinear and analog computation IC functions; noise in ICs, physical origins and device modeling, noise circuit analysis, SNR and NF, and techniques for the enhancement of system noise performance.

EECE 7241. Advanced Solid State Devices. 4 Hours.
Covers state-of-the-art topics in solid-state devices including advanced MOSFET concepts like deep-submicron scaling, HBTs, HEMTs, MESFETs, and other high-frequency/high-speed semiconductor devices.

EECE 7242. Integrated Circuits for Mixed Signals and Data Communication. 4 Hours.
Covers analysis and design of ICs for high-speed communications and mixed-signal processing. Focuses on performance of CMOS and BiCMOS implementations of building blocks for these systems. Covers passive R, L, C, and active devices for ICs; broadband amplifiers, TIAs, limiters, buffers/drivers, muxes, and demuxes; circuit noise modeling and analysis and methods for optimization of SNR and BER, with applications to optical communication; baseband and HF filters; design methods of L-C, OTA-C, MOSFET-C, and switched-C filters; data conversion and D-A and A-D characteristics, popular DAC architectures, serial and parallel ADCs, and high-resolution techniques; clock generators and oscillators, L-C resonator-based designs, VCOs, PLLs and frequency synthesis, and CDR circuits. Requires a verification review of a selected publication relevant to the course. Students who do not meet course prerequisites may seek permission of instructor.

EECE 7243. Integrated Circuit Fabrication. 4 Hours.
Discusses the fundamental aspects of integrated circuit fabrication beginning with the scientific foundations for diffusion, oxidation, ion implantation, chemical and physical vapor deposition, etching, and lithography. Then covers state-of-the-art integrated circuit fabrication technologies in a seminar format.

Introduces microelectromechanical systems, including principles of sensing and actuation, microfabrication technology for MEMS, noise concepts, and packaging techniques. Covers a wide range of disciplines, from electronics to mechanics, material properties, microfabrication technology, electromagnetics, and optics. Studies several classes of devices including inertial measurement devices, pressure sensors, rf components, and optical MEMS. Devotes the last third of the semester largely to projects involving design of MEMS devices to specifications in a realistic fabrication process.

EECE 7245. Microwave Circuit Design for Wireless Communication. 4 Hours.
Covers planar microwave circuits and integrated circuits (MMICs) for wireless communication systems. Employs microwave CAD tools in design projects as well as in-class case-study examples. Reviews communication system basics, modulation and demodulation, architectures of receivers and transmitters, and system performance. Covers planar transmission lines and coupled lines and their application to important devices and microwave circuit functions and multiport networks using S-parameters, flow graphs, and Smith charts. Studies microwave filters, narrowband and broadband amplifiers, their gain and stability, impedance matching, and noise performance, as well as mixers and frequency-conversion techniques. Finishes with design and performance of microwave oscillators. Covers wireless standards, multiple-access techniques, and recent advances if time permits.

EECE 7246. Design and Analysis of Digital Integrated Circuits. 4 Hours.
Explores the analysis and design of basic digital-integrated-circuit logic families. Focuses on CMOS and BiCMOS circuits and covers emitter-coupled logic (ECL). Covers design considerations including propagation delay, switching speed, fan-out, and the effect of parasitics. Discusses noise, cross talk, and interconnect issues as well as bistable circuits and clocks. Correlates design techniques with computer simulations.

EECE 7247. Radio Frequency Integrated Circuit Design. 4 Hours.
Introduces radio frequency (RF) integrated circuit analysis, design, and simulation methods with an emphasis on CMOS implementations. Covers basic RF design concepts including linearity, noise figure, sensitivity, impedance matching, and imperfections of integrated passive components (parasitics, quality factors). Discusses front-end circuit design considerations for low-noise amplifiers, mixers, oscillators, and power amplifiers.

EECE 7250. Power Management Integrated Circuits. 4 Hours.
Presents power management circuits with a focus on modern system on a chip (SoC). Introduces linear regulators, switching converters, switched-capacitor converters, voltage references, energy harvesters, and battery chargers. Studies various control methods, design trade-offs, and performance metrics in the context of an SoC. Introduces emerging energy-harvesting techniques for IC design. After completing this course, the successful student should be able to design, characterize, choose, or specify power-management circuits or ICs for a system.
EECE 7263. Humanoid Robotics. 4 Hours.
Investigates the emerging field of humanoid robotics. Topics may include humanoid designs, software and hardware architectures, sensing and perception, motion planning and control, high-level task planning and control, grasping and manipulation, benchmarking, and experimental methods. Course projects emphasize model-based control of humanoids for completing practical tasks from space exploration to disaster response.

EECE 7269. Special Topics in Electronics, Semiconductor Devices, and Microfabrication. 4 Hours.
Covers aspects of electronics, semiconductor devices, and microfabrication not studied in other courses. Topics may vary from year to year. May be repeated without limit.

EECE 7270. Electromagnetic Theory 2. 4 Hours.
Continues EECE 7202. Examines important electromagnetic applications by the use of advanced mathematical techniques. Topics include general theory of wave-guides and resonators with application to the cylindrical geometry; dielectric rod wave-guide; optical fibers; radiation; linear antennas; loop antenna; linear arrays; ray optics; scattering; and diffraction of waves for planar, cylindrical, and spherical geometries; and effects of random media.

EECE 7271. Computational Methods in Electromagnetics. 4 Hours.
Presents solutions to problems in electromagnetics using a wide variety of numerical and computational methods. Discusses in detail the finite difference approximations of partial differential equations and the finite difference time-domain method of simulating electromagnetic wave propagation and scattering. Uses moment methods to solve the integral equations related to currents and charges on wire structures. Uses finite element and higher-order finite difference methods to solve problems in electrostatics and wave propagation. Discusses efficient matrix methods, relaxation methods, the conjugate gradient technique, and multidimensional Newton's method in the context of electromagnetic field simulation.

EECE 7272. Radar System. 4 Hours.
Provides emphasis on the system's aspects of radar engineering. Topics include basic theory of radar detection, measurement of range, angle, and Doppler shift; classes of radar systems; types of radar noise; components of a radar system; matched filters and correlation receivers as applied to radar systems; and fundamental ideas of radar system analysis. Also explores search radar theory, maximum likelihood estimation approach to measurement of radar target parameters, resolution and ambiguity functions applied to radar, and radar parameter uncertainty principles.

EECE 7273. Remote Sensing. 4 Hours.
Introduces the theory, instruments, and techniques for remote sensing of the earth. Topics include fundamental properties of electromagnetic radiation; matter-energy interaction in the optical and microwave regions; optical imaging systems; synthetic aperture radar and side-looking airborne radar imaging systems; radar polarimetry; microwave scatterometry and radiometry; system considerations, such as temporal and spatial resolution, operating frequency and bandwidth, calibration, measurement precision, and accuracy; data acquisition and storage, such as models and techniques for retrieving geophysical parameters from remotely sensed data; and survey of current and planned airborne and spaceborne remote sensing systems and application of these sensors to measuring geophysical phenomena and monitoring global change.

EECE 7274. Propagation in Artificial Structures. 4 Hours.
Covers effective dielectric and permeability constants in composite materials at high frequencies, electromagnetic wave propagation in electrical and magnetic anisotropic media, magneto-static and magneto-elastic wave propagation in single layer, and electromagnetic wave propagation in multilayers. Requires knowledge of electromagnetic field theory.

EECE 7275. Antennas and Radiation. 4 Hours.
Presents the fundamental theory and properties of antennas. Topics include equivalence, reciprocity, uniqueness, Huygen's principle, antenna impedance, and diffraction; linear, loop, array, and aperture antennas including horns, reflectors, lenses, and microstrip; transmitting and receiving antennas and transmission formulas; and numerical antenna analysis methods.

EECE 7276. Microwave Properties of Materials. 4 Hours.
Discusses general dielectric and magnetic properties of materials, tensor properties of dielectric and magnetic materials, special microwave properties of thin-film materials, and experimental techniques developed in the characterization of microwave materials. Requires knowledge of electromagnetics and materials science.

EECE 7277. Microwave Electron Devices. 1-4 Hours.
Presents the fundamental principles and operation of the principal types of conventional (linear-beam and crossed-field) and novel (maser effect) devices. Topics include interactions of nonrelativistic and relativistic electron beams with electromagnetic fields, linear-beam tubes (klystron, traveling wave tube, backward-wave amplifier, and oscillator), crossed-field tubes (magnetron, forward-and-backward cross-field amplifier, and high-gain CFA), and maser-effect devices (cyclotron maser and gyrotron). May be repeated without limit.

EECE 7280. Fourier and Binary Optics. 4 Hours.
Examines the fundamentals of Fourier and binary optics from a theoretical and a practical viewpoint. Topics include radiation as a wave, polarization of radiation, reflection and refraction at surfaces, optical diffraction, scalar wave equation, Helmholtz and Kirchoff integral theorems, Fresnel and Fraunhoffer diffraction, Green's theorem, interferometry, division of amplitude, division of wave front, diffraction gratings, multilayer filters, interferometric instrumentation, and holography. Also discusses imaging properties of lenses and optical systems, coherent and incoherent imaging, modulation transfer function, spatial filtering, diffraction-limited optical systems, surface design of binary optical elements, miniature and micro-optics, fabrication of diffraction-limited optics, and applications of diffraction-limited optics.

EECE 7281. Fourier Optics. 4 Hours.
Covers current topics of interest in Fourier optics and optical instrumentation. Discusses application of coherence phenomena to optical instrumentation including microdensitometers, microscopes, viewers, cameras, spectrophotometric, and interferometric instruments. Also considers applications of holography, optical data processing and computing, holographic memories, optical modulation, noise and its effects on data collection, synthetic aperture optics, and medical application of laser optics.

EECE 7282. Lasers. 4 Hours.
Introduces basic principles of lasers. Topics include models for the interaction of electromagnetic radiation and matter, laser threshold and rate equations, resonator theory, transverse and longitudinal modes, Rigrod analysis, homogeneous and inhomogeneous broadening, Q switching, cavity dumping, and mode locking. Discusses specific laser types including gas, liquid, and solid, and the applications of lasers and laser systems.
EECE 7284. Optical Properties of Matter. 4 Hours.
Presents the formal mathematical treatment of classical crystal optics including dispersion, polarization, birefringence, metal optics, and the optics of thin films. Emphasis is on the interaction of electromagnetic waves and the crystal lattice. Classical crystal optics are extended to nonlinear effects observed with very intense electric and magnetic fields. Presents applications of nonlinear optics, such as second- and third-harmonic generation, optical mixing, optical parametric oscillation, multiple photon interaction, and linear and nonlinear scattering. Various topics in linear and nonlinear optics are applied in such areas as birefringent filters, second-harmonic generators, optical parametric oscillators, and acousto-optical beam deflectors.

EECE 7285. Opto-electronics and Fiber Optics. 4 Hours.
Covers the fundamentals of the opto-electronic elements that interconnect to create a fiber-optic system for communication and sensing. Discusses the structure of single and multimode fibers, step and graded index fibers, modal theory of fiber propagation, ray theory of multimode fibers, fiber parameters, numerical aperture, Etendue, modal cutoff, couple mode theory, semiconductor physics, diode lasers and LED sources, photovoltaic and photoconductive detectors, coupling sources and detectors to optical fibers, noise in fiber-optic systems, active and passive components, modulators and couplers, fiber interferometry, and applications in communication and sensing.

EECE 7286. IR Imaging. 4 Hours.
Covers the basic concepts necessary for understanding, designing, and evaluating electro-optical systems including modern infrared technology. Emphasis is on considering the system as a whole including radiation sources, the optical collection system, and the detection process. Performance characteristics and system limitations are derived for a variety of imaging and nonimaging systems, as well as for laser devices. Systems to be analyzed may include standard commercial television, night vision devices, laser range finders, thermal imagers, satellite imagers (LANDSAT, SPOT), optical communications, and guidance systems.

EECE 7287. Optical Detection. 4 Hours.
Covers the detector as a component of an optical system. Topics include the laws governing radiation and radiometry, properties of real radiation sources, detailed descriptions of detection devices, noise, contrast, and MTF, imaging and ranging devices, and electro-optical detector systems analysis. Also includes practical consideration in real detectors, resolution and recognition of signals, heterodyne detection, sub-nanosecond pulse detection, and calibration of electro-optical detectors.

EECE 7288. Light and Information. 4 Hours.
Covers the fundamentals of classical and quantum optical signal processing and information theory. Topics include a review of basic wave theory for signal and information processing, classical wave entropy and information, number of degrees of freedom and information capacity of classical imaging systems, information-theoretic wave imaging algorithms, number of degrees of freedom and information capacity of general wave radiation, propagation and scattering systems, basic quantum physics for electrical and computer engineers, quantum bits (qubits), quantum circuits, quantum entanglement, the basics of quantum wave entropy and information, and the basics of quantum information theory. Applications covered include information-theoretic characterization of wireless and antenna systems, fundamental limits in sensors and vision, optical imaging, optical communications, and cryptography.

EECE 7289. Optical Properties of Matter. 4 Hours.
Overview of the basic principles and applications of plasma and gaseous discharges. Topics include gas kinetics, interaction of electrons and ions with static and rf fields, and wave propagation in plasmas. Discusses applications in material processing, space exploration, and microwave devices.

EECE 7290. Plasma Engineering. 4 Hours.
Introduces the basic theory of gaseous discharges. Discusses fluid and kinetic description of collisionless and collisional plasmas with and without magnetic field effects. Emphasis is on linear stability analysis, although also discusses nonlinear effects.

EECE 7292. Plasma Processing Seminar. 4 Hours.
Covers the fundamental physics of plasmas in a lecture format. Students then investigate state-of-the-art plasma processing techniques used in integrated circuit fabrication, MEMS, and other materials processing applications in a seminar format.

EECE 7293. Modern Imaging. 4 Hours.
Covers basic and advanced topics in imaging engineering. Starts with the formulation of typical forward problems in electromagnetic and acoustic wave field propagation and scattering, emphasizing biomedical and nondestructive testing applications, and continues with a survey of imaging methodologies including the so-called qualitative imaging methods. Topics covered are: obstacle scattering, inhomogeneous medium scattering, uniqueness and stability in inverse scattering, imaging with finite data, point-source method and its applications, singular sources and shape reconstruction, linear sampling methods, signal-subspace-based methods, noniterative approaches for the inverse medium problem, intensity-only imaging, estimation theory in imaging and the question of superresolution, and selected topics in compressive sensing and quantum imaging.

EECE 7295. Applied Magnetism. 4 Hours.
Covers the fundamentals of magnetism and magnetic materials, their applications in different industries, and the frontiers of research activities on magnetism and magnetic materials. Includes magnetic units, magnetic classification, origin of ferromagnetism and ferrimagnetism, magnetic anisotropies, magnetostriiction, magnetic domain theory, ferromagnetic/ferrimagnetic resonance, soft magnetic materials, hard magnetic materials, applications of magnetic materials, and information storage.

EECE 7296. Electronic Materials. 4 Hours.
Offers a basic treatment of electronic materials from atomic, molecular, and application viewpoints. Topics include atomic structure and bonding in materials, structure of materials, and crystal defects. These topics lay a foundation for thermal and electronic conduction, which is the underlying physics of electronic devices. Examines the electronic properties of semiconductors, dielectric, magnetic, superconducting, and optical materials. The latter half of the course deals with an introduction to state-of-the-art electronic materials, including semiconductor nanoelectronics, magnetic semiconductors and Spintronics, molecular electronics, carbon nanotubes, conducting polymers, graphene and graphane, and other topics representing recent technological breakthroughs in the area of electronic materials.
EECE 7297. Advanced Magnetic Materials—Magnetic Devices. 4 Hours.
Covers magnetism and magnetic materials, their applications in different industries, magnetic devices, and the frontiers of research activities on magnetism and magnetic materials. Topics include magnetics units, magnetic materials classification, origin of ferromagnetism and ferrimagnetism, magnetic anisotropies, magnetostriiction, magnetic domain theory, ferromagnetic/ferrimagnetic resonance, soft magnetic materials, hard magnetic materials, applications of magnetic materials, information storage, and leading-edge research. Includes lectures on different magnetic sensors—including AMR, GMR, TMR, fluxgate, magnetoelectric sensors, etc.—and on microwave magnetic devices—including tunable filters, phase shifters, isolators, circulators, etc.

EECE 7298. Magnetic Materials—Fundamentals and Measurements. 4 Hours.
Covers the fundamentals of magnetism and magnetic materials, their applications in different industries, and the frontiers of research activities on magnetism and magnetic materials. Includes magnetic units, magnetic materials classification, origin of ferromagnetism and ferrimagnetism, magnetic anisotropies, magnetostriiction, magnetic domain theory, and information storage. Also covers different magnetic material characterization methods, including B-H looper, VSM, MOKE, field-sweep FMR, frequency-sweep FMR, permeameters, etc.

EECE 7309. Special Topics in Electromagnetics, Plasma, and Optics. 4 Hours.
Covers aspects of electromagnetics, plasma, and optics not studied in other courses. Topics may vary from year to year. May be repeated without limit.

EECE 7310. Modern Signal Processing. 4 Hours.
Covers theory and practice of modern signal processing techniques with emphasis on optimal filtering and multirate signal processing. Includes the principle of orthogonality, Wiener and Kalman filters, linear prediction, spectral factorization, the Yule-Walker equations, decimation and interpolation, Noble identities and polyphase representation, and maximally decimated filter banks.

EECE 7311. Two Dimensional Signal and Image Processing. 4 Hours.
Examines the fundamentals of two-dimensional signal processing, with emphasis on image processing. Topics include signals, systems, and transforms in two dimensions; design and analysis of FIR and IIR filters; DFT and FFT algorithms; generation of digital image from the source; image digitizers and display devices; image transforms; techniques for point-wise, local, and global image enhancement; statistical image restoration techniques including recursive estimation; image coding techniques in spatial and transform domain including coding for facsimile transmission; and feature analysis. Requires a good understanding of linear systems, transform techniques, linear algebra, and random processes.

EECE 7312. Statistical and Adaptive Signal Processing. 4 Hours.
Uses linear mean square estimation concepts to explore some important areas of statistical and adaptive signal processing. Offers students an opportunity to gain a thorough understanding and working knowledge of FIR Wiener filtering, linear prediction, and autoregressive model matching; autocorrelation estimation and the deterministic least squares method; LMS and RLS adaptive filters; order recursive (triangular and lattice) architectures; and beamforming in antenna arrays. Emphasizes performance analysis of adaptive filters under nonstationary conditions; triangular covariance factorization; geometric derivation of RLS adaptive algorithms; a factual knowledge of some basic concepts concerning fundamentals of regularized least squares and the Kalman filter interpretation of the RLS algorithm; IIR (Laguerre-based) lattice configuration; and nonlinear adaptive filtering.

EECE 7313. Pattern Recognition. 4 Hours.

EECE 7314. Auditory Signal Processing. 4 Hours.
Offers particular relevance to engineers interested in the processing and production of audio signals including speech, music, and audible noise. Discusses how sounds are processed and perceived in the auditory system by exploring physiological and psychological acoustics. Emphasis is on mathematical models of the auditory system. Topics include properties of acoustical stimuli; anatomy and physiology of the auditory system; electrical recordings from the auditory system; acoustic emissions from the ear; nonlinear, positive feedback model of cochlear mechanics; methods of psychophysical measurements; absolute thresholds; temporal integration; masking and auditory frequency analysis; signal detection theory applied to the auditory system; experiments on and models of auditory discrimination; temporal processing in the auditory system including gap detection thresholds and models of temporal processing; loudness; Zwicker’s loudness summation model; pitch of simple and complex tones; and binaural hearing. Explores practical applications of psychoacoustics.

EECE 7315. Digital Image Processing. 4 Hours.
Focuses on generation of digital image from the source; image digitizers and display devices; image transforms; enhancement techniques, such as histogram, equalization, and edge sharpening; restoration by Wiener and Kalman filters; image coding using run-length coding; DPCM; transform coding; and feature analysis. Undergraduate course in digital signal processing highly recommended but not required.

EECE 7316. Modern Spectral Analysis and Array Processing. 4 Hours.
Describes the problem of estimating spectra from finite records of noisy data and reviews applications including communications (especially wireless), biomedicine, geophysics, speech, nondestructive testing, and sonar and radar. Explores common power spectrum estimation algorithms. Emphasizes the advantages and limitations of conventional, Capon’s, multiple window, maximum entropy, parametric (AR, MA, and ARMA), and harmonic decomposition ( Prony, Pisarenko, and SVD) methods, in terms of accuracy (bias), reliability (variance), applicability, and other criteria. Introduces higher-order and nonstationary spectrum estimation including conventional and parametric higher-order methods and sliding window (short-time Fourier transform and model-based), adaptive, time-frequency, and wavelet techniques for the nonstationary problem. Examines extensions to multichannel and multidimensional data, discusses the array processing problem from a spectrum estimation perspective, and introduces the wave-field perspective. Discusses nonparametric and parametric array processing techniques and applications.
EECE 7317. Digital Filter Banks and Wavelets. 4 Hours.
Develops the theory and applications of perfect reconstruction digital filter banks (PR filter banks) and continuous-time wavelet and wave-packet representations. The mathematical structure of the two disciplines are shown to be intimately related and the theory of both is developed from a signal processing and an abstract mathematical viewpoint. Examines applications that include signal processing and digital communications. Emphasis is on the multiresolution analysis (MRA) of discrete and continuous-time signals and to applications that make use of this paradigm. Requires a strong understanding of digital signal processing, modern signal processing, and linear systems/vector spaces.

EECE 7323. Numerical Optimization Methods. 4 Hours.
Introduces fundamental theoretical and algorithmic concepts behind numerical optimization theory for objective functions with finite numbers of parameters. Optimization problems arise ubiquitously in all areas of engineering and science. Presents established numerical methods for iterative unconstrained and constrained optimization. Topics covered include line-search and trust-region strategies, gradient descent and Newton methods and their variations, linear and quadratic programming, penalty-augmented Lagrangian methods, sequential quadratic programming, and interior point methods. The course relies on the use of Matlab in projects. Requires a basic knowledge of calculus and linear algebra.

EECE 7327. Special Topics in Signal Processing 1. 4 Hours.
Covers aspects of signal processing not studied in other courses. Topics may vary from year to year. Topics may include physics-based image restoration methods for subsurface sensing problems, fundamentals of linear and nonlinear inverse problems, wave-field signal processing, and tomographic imaging. May be repeated without limit.

EECE 7328. Special Topics in Signal Processing 2. 4 Hours.
Covers aspects of signal processing not studied in other courses. Topics may vary from year to year. Topics may include physics-based image restoration methods for subsurface sensing problems, fundamentals of linear and nonlinear inverse problems, wave-field signal processing, and tomographic imaging. May be repeated without limit.

EECE 7329. Special Topics in Signal Processing 3. 4 Hours.
Covers aspects of signal processing not studied in other courses. Topics may vary from year to year. Topics may include physics-based image restoration methods for subsurface sensing problems, fundamentals of linear and nonlinear inverse problems, wave-field signal processing, and tomographic imaging. May be repeated without limit.

EECE 7330. Multi-User Detection. 4 Hours.
Focuses on the fundamentals of joint data detection for cochannel users. Applications include magnetic recording channels and 3G base station design. Topics include the multiaccess channel, long sequences, random sequences, carrier modulation, nonantipodal modulation, matched-filter outputs, single-user matched filter, optimal receiver for the single-user channel, probability of error for asynchronous users, asymptotic multiuser efficiency and related measures, coherent single-user matched filter in Rayleigh fading, optimum coherent multiuser detection, minimum error probability in the asynchronous channel, optimum asymptotic efficiency, near-far resistance, performance analysis in Rayleigh fading, optimum noncoherent multiuser detection, decorrelating detector, truncated-window decorrelating detector, coherent decorrelator in the presence of fading, differentially coherent decorrelation, decorrelation for nonlinear modulation, nondecorrelating linear multiuser detection, mmse linear multiuser detection, linear multiuser detection, adaptive mmse linear multiuser detection, blind mmse multiuser detection, decision-driven multiuser detectors, successive cancellation, performance analysis of successive cancellation, and multistage detection.

EECE 7331. Network Communications and Performance Engineering. 4 Hours.
Presents principles for the design and analysis of modern communications networks. Emphasis is on theoretical and practical concepts. Uses the concept of a layered network architecture as a framework for understanding the functions and services of reliable end-to-end communications. Analyzes different switching and multiplexing techniques within the context of network session requirements and network traffic characterization. Introduces performance modeling with intermediate-level problems in queueing theory including MG1 queues, simple queuing networks, the IPP, and the MMPP. Discusses models for transmission, encoding, and fundamental limitations of physical channels as motivation for the development of data-link-layer services. Presents correctness and performance analysis with respect to framing, error detection, and ARQ schemes. Discusses host-to-host communications as a problem of routing and addressing. Discusses routing, emphasizing correctness, stability, and performance of fundamental algorithms. Students gain insight into the problems of adapting traditional routing strategies to high-speed and wireless environments. Considers flow and congestion control strategies within the context of end-to-end session requirements and global network performance. Requires a working knowledge of C programming; an understanding of statistics, discrete-event simulation, and networking is recommended.

EECE 7332. Error Correcting Codes. 4 Hours.
Covers algebra and Galois field theory in detail, as well as linear block codes, Hamming codes, cyclic codes, their encoding and decoding algorithms, BCH and Reed-Solomon codes, the Berlekamp-Massey decoding algorithm, Fourier transform over finite fields, codes in the frequency domain, and frequency domain decoding techniques. Studies bounds on code performance and burst error correcting codes, convolutional codes, their properties, Viterbi algorithm, performance of the ML decoding, sequential decoding of convolutional codes, the Zigangirov-Jelinek algorithm, concatenated codes, array codes, BCJR and SOVA algorithms, turbo codes, iterative decoding schemes, Trellis coded modulation, low-density parity check codes, and coding for fading channels. Requires a knowledge of probability and digital communications.

EECE 7333. Spread Spectrum Communication Systems. 4 Hours.
Introduces the fundamental concepts of spread spectrum communication systems. Studies the basic theory of direct sequence (PN) and frequency hopping (FH) spread spectrum techniques. Topics include direct sequence code generation, acquisition, and tracking; and phase and Doppler tracking. Emphasis is on the performance of uncoded and coded spread spectrum communications in the presence of interference, jamming, and fading environments. Considers the low probability of interception/detection (LPI/LPD) characteristics of spread spectrum techniques in multiuser communication systems. Presents various practical applications of spread spectrum including IEEE 802.11b, HomeRF, and Bluetooth.
EECE 7334. Wireless Communications. 4 Hours.
Treats a diverse range of topics in wireless communications for applications such as cellular mobile radio, personal communication services, and wireless local area networks. Offers a working knowledge of both narrowband and wideband radio propagation models, including multipath fading and shadowing. Explores the system-level design of cellular networks, including the concepts of frequency reuse, channelization, handoff, power control, cell splitting, sectorization, and Erlang capacity. Covers modern multiple-access methods, including code-, space-, time-, and frequency-division multiple access. Compares coherent, differentially coherent, and noncoherent signaling techniques from the perspectives of spectral efficiency, bit error rate, and transceiver complexity. Explores both optimal and practical receiver designs and covers topics such as digital equalization and diversity techniques.

EECE 7335. Detection and Estimation Theory. 4 Hours.
Reviews vector space and stochastic concepts, sufficiency, unbiased estimation, Cramer-Rao bound, Rao-Blackwell theorem, Pitman efficiency, maximum likelihood estimation, Bayesian estimation, minimum mean squared error estimation, least squares estimation, and Gauss-Markov theorem. Topics include simple and composite hypotheses, Neyman-Pearson tests, uniformly most powerful tests, invariant tests, CFAR detection, Bayesian detection, minmax detection, nonparametric testing, sequential testing, and quickest detection.

EECE 7336. Digital Communications. 4 Hours.
Covers fundamentals of digital communications and coding and the basic structure of a communication system. Topics include modeling of information sources; entropy; rate distortion function; lossless and lossy source coding theorems; Huffman coding; Lempel-Ziv algorithm; scalar and vector quantization; digital modulation schemes and their spectral characterization including PAM, MPSK, QAM, OQPSK, MSK, pi/4-QPSK, CPFSK, CPM, and GMSP; and orthogonal, biorthogonal, and simplex signaling. Explores optimal receiver design and probability of error derivation for various systems. Covers noncoherent detection and DPSK systems and their performance. Discusses synchronization systems, analysis of PLL in the presence of noise, methods of timing recovery, channel capacity, and Shannon's noisy channel coding theorem. Studies cutoff rate and its communication system design. Other topics include coding systems, linear block codes, soft and hard decision decoding, performance of linear block codes, cyclic codes, convolutional codes, Viterbi decoding, error probability bounds, concatenated codes, MAP decoding, Trellis code modulation, communication over band-limited channels, ISI, Nyquist conditions, raised cosine signaling, partial response signaling, equalization techniques, linear adaptive equalization, decision feedback equalizers, maximum likelihood sequence detection, and communication over fading channels.

EECE 7337. Information Theory. 4 Hours.
Discusses basic properties of entropy and mutual information, Shannon's fundamental theorems on data compression and data transmission in the single-user case, binning, and covering lemmas. Topics include rate distortion theory, feedback in one-way channels, Slepian-Wolf coding of correlated information sources, source coding with side information at the receiver, multiple access channel and its capacity region, and the capacity region of the Gaussian multiple access channel. Also covers broadcast channels, superposition coding, and the capacity region of the degraded broadcast channel; performance and comparison of TDMA, FDMA, and CDMA systems from a theoretical point of view; capacity issues for time-varying channels and channels with memory; relation between information theory and statistics; Stein's lemma; and large deviation theory.

EECE 7338. Local Area Networks and Interworking. 4 Hours.
 Presents fundamental principles on the design and analysis of local area networks (LANs) and internetworking strategies. The traditional definition of a LAN is that it provides high-speed transmission within a limited geographic scope, and ownership is associated with the organization that uses and manages it. An alternative definition is that a LAN provides the physical and link-layer access point to an internetwork. LAN technology provides electrical, physical, and signaling specifications, as well as the rules for transmission on various shared or dedicated media. Today LANs can operate at speeds in the gigabits per second and may span great distances. Internetworking imposes a higher logical-layer abstraction that provides the protocols, algorithms, and devices for interconnecting a mesh of heterogeneous LANs and intermediate networks into an Internet. Guides students through the evolution of LAN technology, from the challenges addressed by engineers designing first- and second-generation LANs to present and future advances. Emphasizes basic algorithms and protocols used for media access control and performance evaluation. Discusses internetworking concepts related to the protocols used in the present-day Internet.

EECE 7339. Testing and Design for Testability. 4 Hours.
Encompasses the theoretical and practical aspects of digital systems testing and the design of easily testable circuits. Topics include defect and fault models, test generation for combinational and sequential circuits, testing measures and costs, functional and parametric test methods, design for testability, built-in self-test, and concurrent testing. Provides the foundations for developing test methods for digital systems and provides the techniques necessary to practice design for testability.

EECE 7340. Broadband Communications Networks. 4 Hours.
Covers the basic principles and fundamental design issues relevant to broadband communication networks and exposes students to current research problems. Broadband networks are designed to support a variety of services and applications. Topics range from SONET and ATM switching to high-speed network control. Other topics include characterization of network traffic and its implications on network design; traffic management, flow control, and congestion control including call admissions control, scheduling, and policing; quality of service-based routing; and multicast routing. Networking technologies reflect current research areas and implementations. Focuses on high-speed wide-area-networking (WAN) technologies including frame relay (FR), asynchronous transfer mode (ATM), and next-generation Internet architecture. Includes lectures, readings from relevant literature, and student presentations.

EECE 7347. Special Topics in Communications 1. 4 Hours.
Covers state-of-the-art advanced topics in communications. Topics are selected from the areas of interest and research of the instructor. The prerequisites are determined by the instructor. May be repeated without limit.

EECE 7348. Special Topics in Communications 2. 4 Hours.
Covers state-of-the-art advanced topics in communications. Topics are selected from the areas of interest and research of the instructor. The prerequisites are determined by the instructor. May be repeated without limit.

EECE 7349. Special Topics in Communications 3. 4 Hours.
Covers state-of-the-art advanced topics in communications. Topics are selected from the areas of interest and research of the instructor. The prerequisites are determined by the instructor. May be repeated without limit.
EECE 7350. Software Engineering 1. 4 Hours.

Presents traditional methods in software engineering. Includes the various development models, requirements, specification, design, prototyping, implementation, test, and maintenance. Discusses object-oriented design principles, such as encapsulation, inheritance, and polymorphism. A software project is assigned that contrasts the differences between function-oriented and object-oriented design. Requires a working knowledge of C programming language.

EECE 7351. Software Engineering 2. 4 Hours.

Continues EECE 7350. Focuses on a very specific issue, modular design of software. Explores issues of stepwise-refinement and top-down design in depth and considers organizational/data-flow issues.

EECE 7352. Computer Architecture. 4 Hours.

Presents many of the issues involved in the design and analysis of new and evolving computer architectures. Topics include all aspects of the system including the microprocessor, memory, I/O, and networking. Emphasizes the connection between architecture and the underlying software that drives it. Topics include pipelining, superscalar, out-of-order execution and completion, data flow, caching, prefetching, virtual memory, RAID, and ATM switching. Performance analysis is another fundamental theme of this course. A project is assigned that involves the creation of a trace-driven simulation model to study the performance of various hardware or software architectural features. Also provides a survey of the current state of the art in processor architectures and provides additional readings from recent research in the field. Requires a working knowledge of C programming language.

EECE 7353. VLSI Design. 4 Hours.

Covers all aspects of VLSI design and engineering including VLSI design methodology; MOS transistors and circuits; CAD tools to create, extract, simulate, and evaluate physical layouts; CMOS fabrication process; evaluation and optimization of circuit area, power consumption, and propagation delay; CAD tools to design CMOS systems with standard cells; system clocking design and evaluation; the characteristics and limitations of CAD tools, such as simulation, placement, and routing; VLSI testing, fault models, test vector generation, and design for testability; design projects going through a complete VLSI design cycle; and a research project targeting a specific area of VLSI engineering. Requires a knowledge of electronics and digital systems design.

EECE 7354. VLSI Architecture. 4 Hours.

Augments the physical-level VLSI design knowledge built in EECE 7353 by studying how to take advantage of VLSI technologies. Provides students with the opportunity to go through the design process of VLSI architectures with two architectural-level design projects. Prior project examples include the design and evaluation of FPGAs, application specific processors, and microprocessors. Emphasizes performance and cost tradeoffs and decision making in these projects. Lectures provide theories and discussions to support these design projects that include a brief review of VLSI design methodology, pipelining and parallel processing in VLSI processors, interconnection between VLSI processing units, VLSI-oriented algorithms and applications, VLSI architecture synthesis, such special VLSI architectures as synchronous and asynchronous processor arrays and massively parallel fine-grained processor arrays, and reconfigurable VLSI architectures.

EECE 7355. Digital Systems Design with Hardware Description Languages. 4 Hours.

Covers design, simulation, modeling, synthesis, verification, and implementation of complex digital systems using high-level computer hardware description languages (HDL), beginning with a description of digital system design hierarchy and abstraction. Provides a brief overview of available design tools and simulation programs. Continues with a complete presentation of the standard VHDL hardware description language and how to use this language for design and verification of digital systems at different levels of abstraction. Includes the following topics: CPU design; synthesis of a large design; FPGA implementation of a complete design; and, for materializing this complete design, coding for synthesis, use of verification libraries, and how to program FPGAs and CPLDs. Uses advanced simulation, synthesis, and FPGA programming tools.

EECE 7356. Digital Systems Design and Interfacing with Verilog. 4 Hours.

Covers automated design and synthesis of digital systems with the standard Verilog hardware description language, with an emphasis on CPU structures and interfacing. Demonstrates how Verilog can be used for simulation, synthesis, and test of digital systems. Discusses hardware description using predefined parts, using the bussing structure of a system, or using a mapping of inputs to outputs. After a complete presentation of the Verilog language, presents synthesizability concepts and templates for logic unit, memory unit, and state machine synthesis. Continues by using Verilog in a complete design and design of a CPU, its peripheral devices, and generation of a complete CPU board.

EECE 7357. Fault-Tolerant Computers. 4 Hours.

Overviews fault-tolerant computing and the design and evaluation of dependable systems, and provides a base for research in fault-tolerant systems. Quantitative evaluation and modeling provide the foundation for study of fault avoidance, fault detection, and fault removal from the component level to the system level. Analyzes contemporary and historical architectures. Software evaluation tools are available for the class to explore fault-tolerant design spaces.

EECE 7358. Parallel Architecture for High-Performance Computing. 4 Hours.

Introduces models of parallel computation, network architectures used for parallel processing (ring, mesh, and hypercube, etc.), message routing mechanisms, point-to-point and collective communication primitives (one-to-all, all-to-all, scatter, gather, etc.), parallel and distributed systems performance, and scalability evaluation methods. Discusses how a sequential algorithm can be transformed systematically into a parallel computational strategy so that it can be realized either in hardware (using an application-specific architecture) or in software (using a network of distributed general-purpose computers). Uses numerical algorithms to highlight the key issues involved in this mapping. Includes case studies of high-performance scalable parallelization strategies for computationally intensive operations, such as dense and sparse linear system solvers, multidimensional data transforms, etc., which are often encountered in scientific and multimedia applications. Introduces students to parallel programming using intermediate-level C/MPICH.

EECE 7359. Multiprocessor Architectures. 4 Hours.

Presents the issues related to designing and programming tightly coupled shared-memory multiprocessor systems. Covers memory structure, snoopy and directory-based caching, memory consistency protocols, cache coherency protocols, processor interconnect strategies, and multiprocessor scalability. Covers issues related to program execution of real applications on a multiprocessor system including synchronization primitives, task scheduling, and memory allocation. Requires familiarity with computer architecture.
EECE 7360. Combinatorial Optimization. 4 Hours.
Introduces combinatorial optimization, an emerging field that combines techniques from applied mathematics, operations research, and computer science to solve optimization problems over discrete structures. Emphasizes problems that arise in the areas of electrical and computer engineering including VLSI, computer-aided design, parallel computing, computer architecture, and high-performance compiling. Covers the foundations of algorithm analysis including asymptotic notation and complexity theory, and a range of optimization techniques including divide and conquer, local optimization, dynamic programming, branch and bound, simulated annealing, genetic algorithms, approximation algorithms, integer and linear programming, matroid theory, and greedy algorithms. Considers the efficient generation of optimal solutions, the development and evaluation of heuristics, and the computation of tight upper and lower bounds.

EECE 7361. Digital Hardware Synthesis. 4 Hours.
Introduces techniques and tools for the automatic synthesis of digital systems. Focuses on algorithms for translating a high-level specification into an implementation. Covers a brief introduction to hardware description languages (HDL), automatic translation of the HDL to an intermediate format, architectural synthesis of the register transfer-level implementation, automatic state machine synthesis, and logic synthesis. Requires a completed research project in the automatic synthesis of digital designs.

EECE 7362. Network Computing. 4 Hours.
Studies the theory and practice of analysis and design of network-based computing systems in which programs can be executed adaptively in a changeable computing environment, such as clusters of workstations or PCs. Includes distributed shared memory; cache coherence; snooping; locking; atomic exchange; deadlock; message passing interface (MPI-1 and MPI-2); point-to-point communication; collective communications; and groups, contexts, and communicators. Studies process topologies (virtual topologies), network of workstations (NOW), protocols and programming, scalable coherent interface (SCI) using point-to-point connection of distributed shared memory (DSM) machine, SCIs, cache coherence protocol, clusters of workstations based on SCI, scalable networks for data processing topologies, wormhole routing, deadlock avoidance, scalability, message format, fault tolerance, arbitration policies, and performance evaluation of network-based computing systems. Includes ServerNet, myrinet, and clusters of advanced workstations case studies.

EECE 7363. Interconnection Network for Multicomputers. 4 Hours.
Covers static interconnection networks, topological properties of static interconnection networks, dynamic networks, routing in multicomputer networks, path setup, path selection (deterministic and adaptive), network flow control (store and forward, virtual cut-through, and wormhole), deadlocks in routine (virtual networks), multicasting and broadcasting in static networks (one-to-all, all-to-all broadcasting, and spanning graphs), fault tolerance and reliability of interconnection networks, and performance metrics for different topologies (throughput, message latency, max delivery time, saturation point, hot spots, stable state, average link usage, and dynamic hot spots identification). Also studies modules for a realization of interconnection networks, Node's architecture and organization, based on 32- and 64-bits CPU. Case studies include different topologies and routine strategies.

EECE 7364. Mobile and Wireless Networking. 4 Hours.
Introduces the fundamental techniques and protocols in first- and second-generation, and emerging third-generation, wireless systems. Examines how mobility affects networks, systems, and applications. Mobility of devices and end-users has behavioral implications at all layers of the Internet protocol stack, from the MAC layer up through the application layer. Handling mobility efficiently requires more information sharing between network layers than is typically considered. Topics include cellular system, medium access control protocols for wireless systems, mobility management and signaling within mobile networks, common air interfaces (AMPS, IS-136, IS-95, or GSM), wireless data networking (CDPD), ad-hoc networks, Bluetooth, Mobile IP, and PCS systems. Also introduces students to the problems and current research in the provision of quality of service (QoS) in wireless networks. Methodology includes lectures, textbooks, and emphasis on readings from relevant literature.

EECE 7365. Distributed Systems. 4 Hours.
Covers fundamentals of distributed systems, distributed computing models, client-server computing, remote procedure calls, distributed file and directory services, distributed systems design and implementation issues, reliability and availability, security, overview of computer networks, and case studies in distributed systems. Requires knowledge of operating systems.

EECE 7366. Special Topics in Computer Engineering 1. 4 Hours.
Covers topics in computer engineering not studied in other courses. Subject matter may change from year to year. Topics may include computer architecture, design automation, parallel computing, VLSI, networks, compilers, algorithm design, fault-tolerance, and testing. May be repeated without limit.

EECE 7367. Robotics and Automation Systems. 4 Hours.
Explores methods of operation of general-purpose and industrial manipulator systems, kinematic and dynamic models of mechanical arms, joint solutions and motion characteristics, trajectory planning, arm control through coordinate transformations, classical feedback methods and modern closed-loop control techniques, and real-time control of robotic systems.

EECE 7368. High-Level Design of Hardware-Software Systems. 4 Hours.
Presents state-of-the-art methods, tools, and techniques for system-level design and modeling of complete multiprocessor systems from specification down to implementation across hardware-software boundaries. Recognizes that system complexities are growing exponentially, driven by ever-increasing application demands and technological advances that allow one to put complete multiprocessor systems on a chip (MPSoCs). System-level design that jointly covers hardware and software is one approach to address the associated complexities in the design process and the market pressures. Using system-level design languages (e.g., SpecC, SystemC), offers students an opportunity to specify, simulate, analyze, model, and design hardware-software systems based on examples of typical embedded applications. Requires working knowledge of C/C++, algorithms, and data structures.
EECE 7370. Advanced Computer Vision. 4 Hours.
Offers students an opportunity to obtain practical knowledge in computer vision and to develop skills for being a successful researcher in this field. The goal of the field of computer vision is to make useful decisions about real physical objects and scenes based on sensed images. Achieving this goal requires obtaining and using descriptions (models) of the sensors and the world. Computer vision is an exciting field that builds on very diverse disciplines such as image processing, statistics, pattern recognition, control theory and system identification, physics, geometry, computer graphics, and machine learning. Course material includes state-of-the-art in the field, current research trends, and algorithms and their applications, with an emphasis on the mathematical methods used.

EECE 7374. Fundamentals of Computer Networks. 4 Hours.
Focuses on fundamental concepts of computer networks with a particular focus on the Internet. Covers the language and practices of computer networking at all levels of various network protocol stacks. Basic concepts include general definitions and network organization. Delves into the protocol stack following a top-down approach, covering the application layer (with Internet applications); the transport layer, with its functions and services (e.g., the TCP protocol); the network layer, with a discussion on forwarding and routing and the IP protocol; and the data link layer, with an emphasis on multiaccess. Concludes with current topics including networks analysis/modeling, physical layer/cross-layer design, emerging technologies, and mobility.

EECE 7376. Operating Systems: Interface and Implementation. 4 Hours.
Covers fundamentals of operating systems (OS) design, including theoretical, OS-generic design considerations as well as the practical, implementation-specific challenges in the development of a real OS. Requires proficiency in the C programming language, the GNU tool set for C programming, and debugging in Unix operating systems.

EECE 7387. Special Topics in Computer Networks. 4 Hours.
Covers current aspects of computer communications networks not covered in previous courses. Subject matter may change from year to year. Topics may include wireless ad hoc networks, quality of service in wireless networks, network and Internet security, modeling and analysis of network traffic and mobility, and advanced queuing. May be repeated without limit.

EECE 7388. Special Topics in Computer Engineering 2. 4 Hours.
Covers topics in computer engineering not studied in other courses. Subject matter may change from year to year. Topics may include computer architecture, design automation, parallel computing, VLSI, networks, compilers, algorithm design, fault tolerance, and testing. May be repeated without limit.

EECE 7389. Robot Vision and Sensors. 4 Hours.
Examines methods of acquisition, representation, and processing of real-world information for robot control. Focuses on the different aspects of robot vision. Topics include projection, lens distortion, image noise reduction, texture, edge-based systems, region-based systems, Hough space, matched filtering, object modeling, stereo vision, motion, and optical flow. Robot sensors covers a variety of sensor types including force/torque, proximity, and tactile sensors.

EECE 7390. Computer Hardware Security. 4 Hours.
Presents the foundations for understanding the new and evolving area of hardware security and trust, which have become major concerns for national security over the past decade. Coverage includes security and trust issues in all types of electronic devices and systems, such as ASICs, COTS, FPGAs, microprocessors/DSPs, and embedded systems. Topics encompass the state-of-the-art research fronts such as hardware support for system security, hardware implementations of security primitives, physical attacks and tamper resistance, analysis and practices of side-channel attacks and countermeasures, security for RFID tags, physically unclonable functions, design for hardware trust, hardware Trojan detection and localization, etc. Requires solid knowledge of digital system design, integrated circuits synthesis flow, and embedded systems recommended.

EECE 7393. Analysis and Design of Data Networks. 4 Hours.
Introduces fundamental concepts and approaches for the analysis and design of data networks. Covers delay models, multi-access communication, scheduling, routing, congestion control, and network coding. Presents analytical techniques such as basic queueing theory, queuing networks, optimization, stochastic control, and distributed algorithms. Requires knowledge of basic probability.

EECE 7394. Networks and Systems Security. 4 Hours.
Focuses on network and systems security, providing a broad overview of a diverse range of topics across these two domains. Builds from foundational security models and principles to examine attacks and defenses in systems code, the Web, and mobile platforms. Emphasizes practical techniques in support of the high-level goal to impart the "attacker’s mind-set." Requires comfort with UNIX/Linux systems; networking (TCP/IP); C and/or C++; and Python, Ruby, or another scripting language.

EECE 7397. Advanced Machine Learning. 4 Hours.
Presents topics in advanced machine learning. Presents materials in the current machine learning literature. Focuses on graphical models, latent variable models, Bayesian inference, and nonparametric Bayesian methods. Seeks to prepare students to do research in machine learning. Expects students to read conference and journal articles, present these articles, and write an individual research paper. CS 7140 and EECE 7397 are cross-listed.

EECE 7398. Special Topics. 4 Hours.
Covers topics of interest to the faculty member conducting this class for advanced study. May be repeated without limit.

EECE 7399. Preparing High-Stakes Written and Oral Materials. 4 Hours.
Focuses on how to think through and develop critical materials that have high-stakes impact. These could include writing a compelling technical paper or a winning proposal for external funding, making a compelling oral presentation for a job interview or thesis defense, or presenting arguments to a CEO about strategic directions for a complex project. Includes hands-on exercises and class exercises around challenges defined by the instructor or by guest lecturers.

EECE 7400. Special Problems in Electrical Engineering. 1-4 Hours.
Offers theoretical or experimental work under individual faculty supervision. May be repeated without limit.

EECE 7674. Master's Project. 4 Hours.
Offers analytical and/or experimental work leading to a written report and a final short presentation by the end of the semester.

EECE 7962. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.
EECE 7990. Thesis. 4-8 Hours.
Offers analytical and/or experimental work conducted under the auspices of the department. May be repeated once.

EECE 7996. Thesis Continuation. 0 Hours.
Offers analytical and/or experimental work conducted under the auspices of the department.

EECE 8400. Advanced Seminar. 4 Hours.
Offers treatment of advanced topics of research to include theoretical as well as experimental aspects. Requires reports and discussion of selected technical articles in professional journals and symposia.

EECE 8960. Exam Preparation—Doctoral. 0 Hours.
Offers students an opportunity to prepare for the PhD qualifying exam under faculty supervision. Requires permission of advisor; intended for students who have completed all required PhD course work and have not yet achieved PhD candidacy; students who have not completed all required PhD course work are not allowed to register for this course. May be repeated once.

EECE 8984. Master’s Research. 1-8 Hours.
Offers investigation of master’s research topic under supervision of individual faculty member. May be repeated without limit.

EECE 8986. Research. 0 Hours.
Offers students an opportunity to conduct full-time research under faculty supervision. May be repeated without limit.

EECE 9000. PhD Candidacy Achieved. 0 Hours.
Indicates successful completion of program requirements for PhD candidacy.

EECE 9803. PhD Seminar. 0 Hours.
Requires the student to present a seminar to the Department of Electrical Engineering on a subject related to his/her PhD thesis. The thesis supervisor coordinates the seminar. Requires passing of PhD qualifying exam.

EECE 9984. Doctoral Research. 1-8 Hours.
Investigates doctoral research topic under supervision of individual faculty member. May be repeated without limit.

EECE 9986. Research. 0 Hours.
Offers students an opportunity to conduct full-time research under faculty supervision. May be repeated without limit.

EECE 9990. Dissertation. 0 Hours.
Offers theoretical and/or experimental work conducted under the auspices of the department. Required to be taken in two consecutive semesters. Includes attendance at Distinguished Lecture Series (DLS). May be repeated once.

EECE 9996. Dissertation Continuation. 0 Hours.
Offers continued dissertation work conducted under the supervision of a departmental faculty member. Includes attendance at Distinguished Lecture Series (DLS). Requires prior completion of EECE 9990 twice. May be repeated without limit.