

# DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

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The Department of Electrical and Computer Engineering prepares students for highly competitive, national placement in electrical and computer engineering employment and graduate education by providing a thorough grounding in electrical science and design, together with a sound foundation in mathematics, basic sciences and life skills.

The department offers baccalaureate degrees in computer engineering and electrical engineering, in addition to minors in both areas, as well as the option to choose course work appropriate for a pre-medicine or pre-dentistry curriculum. An electrical and computer engineering track is available in the Master of Science in Engineering as well as the Ph.D. in Engineering. The track is designed to prepare students for practice, research and/or teaching of electrical and computer engineering at the advanced level by providing intensive preparation for professional practice in the microelectronics, nanoelectronics, computer engineering, and controls and communications aspects of electrical and computer engineering. At the advanced level, this track prepares individuals to perform original, leading-edge research in the broad areas of microelectronics, nanoelectronics, controls and communications, and computer engineering.

The curricula of the department provide a strong foundation in the fundamentals of the profession, including engineering problem-solving, breadth in the major facets of the profession and the opportunity to specialize in today's critical areas of computer engineering, communication systems and microelectronics. Graduates will be well prepared for constant technological change and growth through lifelong learning.

## **EGRE 521. Advanced Semiconductor Devices. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRE 303, PHYS 420 and 440, or equivalents or permission of instructor. Studies the fundamentals of semiconductor heterojunctions, metal-semiconductor contacts, metal-oxide-semiconductor structures, defects, interface states, scaled MOS transistors and heterojunction bipolar transistors.

## **EGRE 525. Fundamentals of Photonics Engineering. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRE 303, 309 and 310 or equivalents. An introduction to the interaction of electromagnetic lightwaves with solid-state materials. Based on the quantum mechanics of photon emission and absorption, the generation and detection of coherent light by semiconductor lasers and photodetectors are investigated. Optical waveguides also are studied for use in sensors employing interferometric and evanescent-field principles. Examples of integrated photonic sensors are presented for mechanical, chemical and biological systems.

## **EGRE 526. Computer Networks and Communications. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 312. Theoretical and applied analysis of basic data communication systems; design of networks in the framework of the OSI reference model; Local and Wide Area Networks; performance analysis of networks; error control and security. Students will work in teams to design and implement a small computer network. Crosslisted as: CMSC 506.

## **EGRE 531. Multicore and Multithreaded Programming. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 364 or CMSC 311 or permission of instructor. Introducing multicore architectures, multithreaded programming models, OpenMP, Pthreads, thread synchronization, performance evaluation and optimization, load balancing and software tools for multicore/multithread programming.

## **EGRE 532. GPU Computing. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: CMSC 502, EGRE 531 or permission of instructor. The primary objective of this course is to provide students with knowledge and hands-on experience in developing application software for graphics processing units. The course concentrates on parallel programming basics, GPU hardware architecture and software, GPU programming techniques, GPU performance analysis and optimization, and application development for GPUs.

## **EGRE 535. Digital Signal Processing. 3 Hours.**

Semester course; 2 lecture and 3 laboratory hours. 3 credits. Prerequisites: EGRE 337 or consent of instructor. The course focuses on digital signal processing theory and algorithms, including sampling theorems, transform analysis and filter design techniques. Discrete-time signals and systems, and filter design techniques are treated. Several applications of DSP in telecommunications, image and video processing, and speech and audio processing are studied.

## **EGRE 540. RF Communications and Antennas. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 309 or equivalent or permission of instructor. Basics of electromagnetics and passive RF components such as filters, isolators, tuners, phase shifters, resonators and tees are discussed, along with design and characterization of wire and planar antennas.

## **EGRE 541. Medical Devices. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Enrollment requires permission of instructor. An introduction to engineering applications in medicine and design principles for next-generation medical devices. Topics include early cancer detection using microwaves, wireless data telemetry using implantable or body-centric systems, implantable sensors, biodegradable sensors, hyperthermia/ablation for cancer treatment, magnetic resonance imaging, and deep brain and nerve stimulation.

## **EGRE 553. Industrial Automation. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRE 246 and EGRE 254, or permission of the instructor. Enrollment restricted to students with senior or graduate standing in the School of Engineering. This course provides an introduction to the systems, techniques and languages used in the control of manufacturing and process industries. Major topics include programmable logic controller operation and programming, supervisory control and data acquisition systems, and human machine interfaces. Other topics include an introduction to feedback control systems, analog-to-digital and digital-to-analog conversion, sensors and transducers, and actuators and motors.

**EGRE 554. Advanced Industrial Automation. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 553. This course provides additional instruction on topics related to systems, techniques and languages used in the control of manufacturing and process industries. Major topics include advanced PLC programming and operation, motion control, and HMI programming. Other topics include feedback control systems, industrial networking and system simulation.

**EGRE 555. Dynamics and Multivariable Control I. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 301 and 310 or the equivalent. Systems of differential equations with controls, linear control systems, controllability, observability, introduction to feedback control and stabilization. Crosslisted as: MATH 555.

**EGRE 573. Sustainable and Efficient Power Systems. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRE 309 or EGRE 471 or permission of instructor. The course covers distributed power generation system and renewable energy technologies. It introduces models and tools for investigating electric power generation and efficiency analysis, the wind and solar power, energy storage, renewable integration, and environmental impacts. At the completion of the course students will be able to apply appropriate models and complete a feasibility study of practical renewable energy systems.

**EGRE 591. Special Topics in Electrical and Computer Engineering. 1-4 Hours.**

Semester course; variable hours. 1-4 credits. Prerequisite: senior or graduate standing in the School of Engineering or permission of the instructor. Lectures, tutorial studies, library assignments in selected areas of advanced study or specialized laboratory procedures not available in other courses or as part of research training.

**EGRE 620. Electron Theory of Solids. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 420 and 440 or permission of instructor. The study of electronic structures, band structure calculations, optical absorption and emission, lasing in semiconductors, electron-photon interactions, heterostructures and nanostructures. Quantum theory of electron-photon interaction, absorption and emission, semiconductor lasers, linear response transport, Landauer Buttiker formulas, mesoscopic devices and phenomena, resonant tunneling, single electronics, non-equilibrium Green's function formalism, second quantization, coupled mode theory, electrons in a magnetic field, and integer quantum Hall effect.

**EGRE 621. Spintronics. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 620 or equivalent, or with permission of instructor. Basic concept of spin, spin interactions, spin transport, spin-based classical devices, single spintronics and spin-based quantum computing.

**EGRE 622. MEMS Design and Fabrication. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRE 303 and EGRE 334 or permission of instructor. The course provides the background required to conduct research in microelectromechanical systems. The course provides an overview as well as detailed coverage of material properties, specialized fabrication techniques and the fundamental principles of the major classes of MEMS devices. This will include mechanical sensors and actuators, surface acoustic wave devices, optical sensors, modulators and switches, bioMEMS, chemical and biochemical sensors, and microfluidic devices.

**EGRE 624. Nonlinear Optical Materials and Devices. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 525 or equivalent or permission of instructor. This course describes the principles of nonlinear optics and discusses the operation of photonic devices and systems that utilize various second- and third-order nonlinear optical effects. The topics include electromagnetic wave propagation in anisotropic media, nonlinear optical susceptibility tensor, linear and quadratic electro-optic effects, second harmonic, sum- and difference-frequency generation, phase-matching, parametric amplification, optical switching, multi-photon absorption, and self-focusing and self-phase modulation.

**EGRE 625. Clean Room Lab Practicum. 1 Hour.**

Semester course; 3 laboratory hours. 1 credit. Prerequisite: EGRE 334 or permission of instructor. The course develops the detailed knowledge and skills required to design and fabricate advanced microscale and nanoscale devices for doctoral thesis work in a micro- and nano-fabrication facility cleanrooms. The course focuses on fabricating a nanostructured device and involves photolithography, wet and dry etching, oxidations, diffusions and thin film depositions. Students will complete the processing of the device and perform characterization experiments. Design skills will also be developed, including design and layout using software tools and fabrication of custom photomasks. Students will document all aspects of the laboratory work.

**EGRE 626. Advanced Characterization of Electronic Materials and Devices. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 303 or permission of instructor. This course discusses crystal symmetry in relation with physical properties of crystalline solids, with special emphasis on semiconductor materials forming the basis of modern electronic and optoelectronic devices, point and extended defects and their effects on electronic and optical properties of semiconductor materials and device performance, and defect formation during processing. The course also covers in depth structural, electrical and optical techniques used to reveal various structural defects: the theory and practice of X-ray, neutron and electron diffraction methods, transmission and scanning electron microscopy, scanning probe microscopy, Hall effect, deep-level transient spectroscopy, photo- and cathodoluminescence, and time-resolved spectroscopy, with particular focus on their applications to real semiconductor materials and device structures.

**EGRE 627. Nanophotonics. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 525 or equivalent or permission of instructor. Advances in nanotechnology and fabrication have allowed scientists to control light like never before, bringing topics of science fiction such as cloaking, unlimited resolution imaging, nanometer-thick optics and breakthrough treatments for disease into the realm of reality. This course explores what is possible when students can confine light at the nanoscale and engineer materials at will, covering topics such as light guiding by metals (plasmonics), optical lattices (photonic crystals), arbitrary materials (meta-materials/surfaces), nanoscale lasers (spasers) and stopping light (static optics). Students are exposed to the newest advances in the field through discussion, projects and presentations.

**EGRE 631. Real-time and Embedded Systems. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 426 or equivalent or permission of instructor. Presents advanced material in the area of the design, implementation and testing of embedded computer systems intended to operate as part of a larger system. Topics to be discussed include design challenges of embedded computing, real-time scheduling theory, worst-case execution time analysis, embedded architectures, embedded software design and performance optimizations. Hands-on labs and a research project on advanced topics in this field will be included in this course.

**EGRE 632. Dependable Embedded Systems. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 364 or permission of instructor. This course explores the rich set of issues that must be considered when dealing with dependable embedded systems in smart energy delivery, transportation, interconnected health and medical devices and smart buildings, which have one or more of the following attributes: need for safety, continuous reliable operation, resilient to disruptions, secure against cyber-attacks, operate in real-time, maintainable and designed correctly. Among the topics covered are fault-tolerant computing, reliability and safety engineering, understanding the origins of failures and errors, design criteria, software reliability, formal verification of designs, cyber security, review of standards in safety critical systems and social/legal concerns.

**EGRE 635. Advanced Computer Architecture. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 426 or with permission of instructor. This course will focus on the design and analysis of high performance computer architectures. Topics investigated include pipeline design, superscalar computers, multiprocessors, memory systems, peripherals, interfacing techniques, networks, performance and software issues. Crosslisted as: CMSC 605.

**EGRE 636. Introduction to Cyber-Physical Systems. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRE 335 and EGRE 365 or equivalents or permission of instructor. This course introduces students to the research, design and analysis of cyber-physical systems – the tight integration of computing, control and communication. The main focus is on understanding existing and emerging models of CPSs, as well as physical processes in terms of differential equations and computational models for discrete time systems, such as extended finite-state machines and hybrid automata. State-charts are introduced and combined with the physical models for analysis of embedded systems. Linear temporal logic is introduced and applied to specify the desired system behavior. Tools for analytical study and verification of the satisfaction of linear temporal logic formulae are presented and discussed in numerous applications. Dependability attributes such as safety, reliability and cyber-security are discussed in the context of high integrity CPSs.

**EGRE 640. Semiconductor Optoelectronics. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 309 or equivalent or permission of instructor. Discussions of optical processes in semiconductors and semiconductor heterostructures in terms of radiative and nonradiative processes, as well as absorption. Also covers in depth the theory and practice of light-emitting diodes, including those intended for solid-state lighting, lasers and detectors.

**EGRE 644. Wireless Communications. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 444 or permission of instructor. The main objective of this course is to introduce the fundamental principles of wireless communications. The focus will be on the physical layer and wireless transceiver design issues. Students are expected to gain a thorough understanding of wireless channel modeling, the concept of channel fading, the means to mitigate the effect of fading through diversity techniques. Some practical wireless communication techniques will also be introduced such as space-time coding, multiple input multiple output communications and orthogonal frequency-division multiplexing.

**EGRE 651. Intelligent Linear Systems. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 337 or permission of instructor. This course covers selected topics on intelligent systems and fundamental principles of system analysis. Emphasis is placed on the student gaining mathematical modeling experience, performing computer simulations and designing systems architecture. Topics include intelligent agents, autonomous control, linear algebraic equations for state variable equations, complex dynamic systems, controllability and observability, linear discriminant functions in algorithm-independent optimization, multilayer neural networks, unsupervised learning and clustering, mobile robot localization and kinematics, and perception for planning and navigation.

**EGRE 656. Estimation and Optimal Filtering. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 310, EGRE 337 and EGRE 555/MATH 555. This course will expose students to the fundamental issues in parameter estimation and recursive state estimation for dynamic systems. Topics covered will include maximum likelihood estimation, maximum a posteriori estimation, least squares estimation, minimum mean square error estimation, Cramer-Rao lower bound, discrete-time Kalman filter for linear dynamic systems, extended Kalman filter for nonlinear problems and system models for the Kalman filter.

**EGRE 671. Power System Operations and Controls. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 471 or equivalent. This course covers the fundamental concepts of economic operation and controls of power systems, including real and reactive power balance, optimized generation dispatch, steady state and dynamic analysis, real-time monitoring and controls, and contingency analysis. Upon completion of this course, students will be able to develop equivalent circuits and compute programs for power flow analysis, define and analyze automatic generation control scheme on a power system, develop generation dispatching schemes, define and analyze state estimation of a power system using analysis programs, and perform contingency studies of the grid.

**EGRE 691. Special Topics in Electrical and Computer Engineering. 1-3 Hours.**

Semester course; 1-3 lecture hours. 1-3 credits. Prerequisites: at least one graduate-level engineering course and permission of instructor. An advanced study of selected topic(s) in electrical and computer engineering. See the Schedule of Classes for specific topics to be offered each semester.

**EGRE 692. Independent Study. 1-3 Hours.**

Semester course; 1-3 lecture and 1-3 laboratory hours. 1-3 credits. Prerequisites: graduate standing and permission of instructor. The student must identify an electrical and computer engineering faculty member willing to supervise the course and submit a proposal for approval to the electrical and computer engineering graduate committee. Investigation of specialized electrical and computer engineering problems through literature search, mathematical analysis, computer simulations and/or experimentation. Written and oral reports, final report and examination are required.

**EGRE 697. Directed Research in Electrical and Computer Engineering. 1-15 Hours.**

Semester course; variable hours. 1-15 credits. Prerequisite: graduate standing or permission of instructor. Research directed toward completion of the requirements for the electrical and computer engineering track in the M.S. or Ph.D. in Engineering performed under the direction of an electrical and computer engineering faculty member and advisory committee. Graded as S/U/F.