Courses primarily for undergraduates:

**E E 166: Professional Programs Orientation**  
(Cross-listed with CPR E). Cr. R. F.S.  
(1-0) Overview of the nature and scope of electrical engineering and computer engineering professions. Overview of portfolios. Departmental rules, advising center operations, degree requirements, program of study planning, career options, and student organizations.

**E E 185: Introduction to Electrical Engineering and Problem-Solving I**  
(2-2) Cr. 3. F.S.  
*Prereq: MATH 143 or satisfactory scores on mathematics placement examinations; credit or enrollment in MATH 165*  

**E E 186: Introduction to Electrical Engineering and Problem Solving II**  
(0-2) Cr. 1. S.  
*Prereq: E E 185*  
Project based and hands on continuation of 185. Group skills needed to work effectively in teams. Individual interactive skills for small and large groups. Learning to use tools and methods for solving electrical engineering problems.

**E E 188: Bio-Electrical Engineering Fundamentals Laboratory**  
(1-3) Cr. 2.  
*Prereq: E E 185 or equivalent*  
Fundamental laboratory based course in bio-electrical engineering with an emphasis on acquiring and analyzing biomedical signals to obtain relevant information. Topics covered include an overview of basic medical terminology and anatomy, labs illustrating data acquisition from different body systems, and an introduction to statistical significance and its relationship to biological variability.

**E E 201: Electric Circuits**  
(3-3) Cr. 4. F.S.  
*Prereq: Credit or enrollment in MATH 267 and PHYS 222*  
Emphasis on mathematical tools. Circuit elements (resistors, inductors, capacitors) and analysis methods including power and energy relationships. Network theorems. DC, sinusoidal steady-state, and transient analysis. AC power. Frequency response. Two port models. Diodes, PSPICE. Laboratory instrumentation and experimentation. Credit for only E E 201 or 442 may be used towards graduation.

**E E 224: Signals and Systems I**  
(3-3) Cr. 4. F.S.  
*Prereq: E E 201, MATH 267, PHYS 222*  

**E E 230: Electronic Circuits and Systems**  
(3-3) Cr. 4. F.S.  
*Prereq: E E 201, MATH 267, PHYS 222*  

**E E 261: Transfer Orientation**  
(Cross-listed with CPR E). Cr. R.  
Introduction to the College of Engineering and the engineering profession specifically for transfer students. Information concerning university and college policies, procedures, and resources. Offered on a satisfactory-fail basis only.

**E E 285: Problem Solving Methods and Tools for Electrical Engineering**  
(3-3) Cr. 4.  
E E 294: Program Discovery
(Cross-listed with CPR E). Cr. R.
Prereq: CPR E 166 or E E 166
The roles of professionals in computer and electrical engineering. Relationship of coursework to industry and academic careers. Issues relevant to today’s world. Offered on a satisfactory-fail basis only.

E E 303: Energy Systems and Power Electronics
(3-0) Cr. 3. F.S.
Prereq: MATH 267, PHYS 222; credit or enrollment in E E 230

E E 311: Electromagnetic Fields and Waves
(4-0) Cr. 4. F.S.
Prereq: E E 201, MATH 265, PHYS 222, credit or enrollment in MATH 267

E E 314: Electromagnetics for non Electrical Engineers
(3-0) Cr. 3.
Prereq: PHYS 222, PHYS 112, or equivalent
Conceptual study of electromagnetism and its application in engineering and related fields. EM fundamentals, EM spectrum, radiation, radiating systems, wireless, modern concepts of physics, quantum computing, transmission lines, high speed effects, waveguides, GPS and other related phenomena will be discussed and explained with the application in mind.

E E 321: Communication Systems I
(3-0) Cr. 3. F.
Prereq: E E 224

E E 322: Probabilistic Methods for Electrical Engineers
(Cross-listed with STAT). (3-0) Cr. 3. F.S.
Prereq: E E 224
Introduction to probability with applications to electrical engineers. Sets and events, probability space, conditional probability, total probability and Bayes’ rule. Discrete and continuous random variables, cumulative distribution function, probability mass and density functions, expectation, moments, moment generating function, multiple random variables, functions of random variables. Elements of statistics, hypothesis testing, confidence intervals, least squares. Introduction to random processes.

E E 324: Signals and Systems II
(3-3) Cr. 4. F.S.
Prereq: E E 224

E E 330: Integrated Electronics
(Cross-listed with CPR E). (3-3) Cr. 4.
Prereq: E E 201, credit or enrollment in E E 230, CPR E 281

E E 332: Semiconductor Materials and Devices
(Cross-listed with MAT E). (3-0) Cr. 3. S.
Prereq: PHYS 222; MAT E majors: MAT E 317; CPR E and E E majors: E E 230
Introduction to semiconductor material and device physics. Quantum mechanics and band theory of semiconductors. Charge carrier distributions, generation/recombination, transport properties. Physical and electrical properties and fabrication of semiconductor devices such as MOSFETs, bipolar transistors, laser diodes and LED’s.

E E 333: Electronic Systems Design
(3-3) Cr. 4. F.
Prereq: E E 230, credit or enrollment in CPR E 288
Further topics in electronic systems design: Use of sensors and actuators. High-power amplifying and switching components. Linear and switched-mode power supplies. Linear and switched-mode amplifiers. Interfacing electronic components with programmable microcontrollers. Printed circuit board technology and design tools. Laboratory exercises and design projects incorporating printed circuit technology.
E E 336: Biomedical Instrumentation
(2-2) Cr. 3.
Prereq: E E 188, E E 224, E E 230
Principles and practices of biomedical instrumentation. Topics include: the physics and measurement of biopotentials including electrocardiography (EKG), electromyography (EMG) and electro-oculography (EOG), mechanical and chemical sensors, amplifiers and filters, recording and processing biological signals from nerve cells, muscles and human body, electrode polarization, surface electrodes, power line interference, heart sound sensors, respiratory gas concentration, blood-gas sensors, noninvasive blood-gas sensors.

E E 351: Analysis of Energy Systems
(3-0) Cr. 3.
Prereq: PHYS 222
Meets International Perspectives Requirement.

E E 388: Sustainable Engineering and International Development
(Cross-listed with A B E, C E). (2-2) Cr. 3. F.
Prereq: Junior classification in engineering
Multi-disciplinary approach to sustainable engineering and international development, sustainable development, appropriate design and engineering, feasibility analysis, international aid, business development, philosophy and politics of technology, and ethics in engineering. Engineering-based projects from problem formulation through implementation. Interactions with partner community organizations or international partners such as nongovernment organizations (NGOs). Course readings, final project/design report.
Meets International Perspectives Requirement.

E E 391: Open Laboratory and Design Studio
(2-2) Cr. 2.
Prereq: E E 224
Studio-based activity (guided problem-based learning and design) focusing on elements of design, measurement, data capture, and data interpretation. Team building, engineering professionalism, engineering process of review and critique, and presentation. Open design activities that may include working with other studios.

E E 394: Program Exploration
(Cross-listed with CPR E). Cr. R.
Prereq: CPR E 294 or E E 294
Exploration of academic and career fields for electrical and computer engineers. Examination of professionalism in the context of engineering and technology with competencies based skills. Introduction to professional portfolio development and construction. Offered on a satisfactory-fail basis only.

E E 396: Summer Internship
Cr. R. Repeatable. SS.
Prereq: Permission of department and Engineering Career Services
Professional work period of at least 10 weeks during the summer. Students must register for this course prior to commencing work. Offered on a satisfactory-fail basis only.

E E 398: Cooperative Education (Co-op)
Cr. R. Repeatable. F.S.
Prereq: Permission of department and Engineering Career Services
Professional work period. One semester per academic or calendar year. Students must register for this course before commencing work. Offered on a satisfactory-fail basis only.

E E 414: Microwave Engineering
(Dual-listed with E E 514). (3-3) Cr. 4. F.
Prereq: E E 230, E E 311
Principles, analyses, and instrumentation used in the microwave portion of the electromagnetic spectrum. Wave theory in relation to circuit parameters. S parameters, couplers, discontinuities, and microwave device equivalent circuits. RF amplifier design, microwave sources, optimum noise figure and maximum power designs. Microwave filters and oscillators.

E E 417: Electromagnetic Radiation, Antennas, and Propagation
(Dual-listed with E E 517). (3-3) Cr. 4. S.
Prereq: E E 311
E E 418: High Speed System Engineering Measurement and Testing
(Cross-listed with CPR E). (3-2) Cr. 4. F.
Prereq: E E 230 and E E 311

E E 419: Magnetism and Magnetic Materials
(Dual-listed with E E 519). (Cross-listed with MAT E). (3-0) Cr. 3. F.
Prereq: E E 311 or MAT E 317 or PHYS 364

E E 422: Communication Systems II
(3-0) Cr. 3.
Prereq: E E 321, E E 322, enrollment in E E 423
Introduction to probability and random processes; Performance of analog systems with noise; Performance of digital communication with noise; optimum receivers, transmission impairments, and error rates; Introduction to information theory and coding: source coding, channel coding, channel capacity.

E E 423: Communication Systems Laboratory
(0-3) Cr. 1.
Prereq: E E 321, enrollment in E E 422
Construction and evaluation of modulators, demodulators and other components for analog and digital communications. Design, simulate, and evaluate wireless communication systems and their key components. Noise measurement.

E E 424: Introduction to Digital Signal Processing
(3-3) Cr. 4.
Prereq: E E 224

E E 432: Microelectronics Fabrication Techniques
(Dual-listed with E E 532). (Cross-listed with MAT E). (2-4) Cr. 4.
Prereq: credit or enrollment in E E 332
Techniques used in modern integrated circuit fabrication, including diffusion, oxidation, ion implantation, lithography, evaporation, sputtering, chemical-vapor deposition, and etching. Process integration. Process evaluation and final device testing. Extensive laboratory exercises utilizing fabrication methods to build electronic devices. Use of computer simulation tools for predicting processing outcomes. Recent advances in processing CMOS ICs and micro-electro-mechanical systems (MEMS).

E E 435: Analog VLSI Circuit Design
(Cross-listed with CPR E). (3-3) Cr. 4. S.
Prereq: E E 324, E E 330, E E 332, and either E E 322 or STAT 330
Basic analog integrated circuit and system design including design space exploration, performance enhancement strategies, operational amplifiers, references, integrated filters, and data converters.

E E 438: Optoelectronic Devices and Applications
(Dual-listed with E E 538). (3-0) Cr. 3.
Prereq: E E 311, E E 332

E E 439: Nanoelectronics
(3-0) Cr. 3. S.
Prereq: E E 332 or MAT E 334
Concepts of quantum mechanics relevant to nanoelectronic devices, including quantization, tunneling, and transport; overview of some of the leading technologies for nanoelectronics, including carbon nanotubes, quantum dots, and molecular transistors; fabrication methods for building nanoelectronic devices.
E E 442: Introduction to Circuits and Instruments
(3-2) Cr. 2. F.S.
Prereq: PHYS 222, MATH 267
Half-semester course. Basic circuit analysis using network theorems with
time domain and Laplace transform techniques for resistive, resistive-
inductive, resistive-capacitive, and resistive-inductive-capacitive circuits.
Transient circuit behavior. Basic operational amplifiers and applications.
Familiarization with common E E instrumentation and demonstration
of basic principles. Credit for only 201 or 442 may be counted toward
graduation; credit for 442 will not count toward graduation for E E or Cpr
E majors.

E E 448: Introduction to AC Circuits and Motors
(3-2) Cr. 2. F.S.
Prereq: E E 442
Half-semester course. Basics of DC machines, stepper motors, AC
induction motors, and synchronous generators. AC steady state analysis,
transformers, and three-phase circuit analysis.

E E 450: Biosensing
(Cross-listed with B M E). (3-0) Cr. 3.
Prereq: B M E 220
Overview of biosensors and bioanalytical challenges; designing for
performance including various analytical problems, ion-selective
membranes, characteristics of enzymes and basics of bioaffinity sensing;
fundamentals of bioselective layers including depositing films and
membranes, surfaces for immobilization and bioselective agents;
survey of different biosensing technologies including electroanalytical,
biomembrane, optical, and acoustic-wave based sensors.

E E 450L: Biosensing Laboratory
(Cross-listed with B M E). (0-3) Cr. 1.
Prereq: B M E 220, concurrent enrollment in B M E 450
Laboratory course accompanying B M E 450. Design, fabrication, and
characterization of various electrical, chemical, polymer, optical and
acoustic sensors.

E E 451: Engineering Acoustics
(Cross-listed with E M, M E). (2-2) Cr. 3. Alt. S., offered even-numbered
years.
Prereq: PHYS 221 and MATH 266 or MATH 267
The basics of acoustic wave propagation in fluids with an emphasis on
sound propagation in air. Topics include transmission and reflection of
sound at a boundary; role of acoustic sources in directing sound fields;
diffraction of sound around solid objects; reverberation of sound in a
room; and the measurement of sound fields.

E E 452: Electrical Machines and Power Electronic Drives
(2-3) Cr. 3. S.
Prereq: E E 303, E E 324
Basic concepts of electromagnetic energy conversion. DC motors and
three-phase induction motors. Basic introduction to power electronics.
Adjustable speed drives used for control of DC, induction, and AC motors.
Experiments with converter topologies, DC motors, AC motors and
adjustable speed drives.

E E 455: Introduction to Energy Distribution Systems
(3-0) Cr. 3. F.
Prereq: E E 303, credit or registration in E E 324
Overhead and underground distribution system descriptions and
characteristics, load descriptions and characteristics, overhead line and
underground cable models, distribution transformers, power flow and
fault analysis, overcurrent protection, power factor correction, system
planning and automation, and economics in a deregulated environment.

E E 456: Power System Analysis I
(3-0) Cr. 3. F.
Prereq: E E 303, credit or registration in E E 324
Power transmission lines and transformers, synchronous machine
modeling, network analysis, power system representation, load flow.

E E 457: Power System Analysis II
(3-0) Cr. 3. S.
Prereq: E E 303, credit or registration in E E 324
Power system protection, symmetrical components, faults, stability.
Power system operations including the new utility environment.

(Cross-listed with ECON). (3-0) Cr. 3.
Prereq: E E 303 or ECON 301
Evolution of electric power industry. Power system operation and
planning and related information systems. Linear and integer
optimization methods. Short-term electricity markets and locational
marginal prices. Risk management and financial derivatives. Basics of
public good economics. Cost recovery models including tax treatment for
transmission investments.
E E 459: Electromechanical Wind Energy Conversion and Grid Integration  
(Dual-listed with E E 559). (3-0) Cr. 3.  
Prereq: Credit or enrollment in E E 452, E E 456  
Summary of industry status and expected growth; power extraction from the air stream; operation and modeling of electric machines, and power electronics topologies for wind energy conversion; analysis of machine-grid power electronic circuits, controller interface, and collector (distribution) networks; treatment of harmonics, flicker, over/under-voltages, filters, low-voltage ride-through, and reactive compensation; relaying; effects on transmission expansion, planning and grid operation and coordination including variability, frequency control, reserves, and electricity markets; overview of storage technologies and hybrid configurations.

E E 465: Digital VLSI Design  
(Cross-listed with CPR E). (3-3) Cr. 4. F.  
Prereq: E E 330  
Digital design of integrated circuits employing very large scale integration (VLSI) methodologies. Technology considerations in design. High level hardware design languages, CMOS logic design styles, area-energy-delay design space characterization, datapath blocks: arithmetic and memory, architectures and systems on a chip (SOC) considerations. VLSI chip hardware design project.

E E 466: Multidisciplinary Engineering Design  
(Cross-listed with A B E, AER E, B M E, CPR E, ENGR, I E, M E, MAT E). (1-4) Cr. 3. Repeatable. F.S.  
Prereq: Student must be within two semesters of graduation; permission of instructor.  
Application of team design concepts to projects of a multidisciplinary nature. Concurrent treatment of design, manufacturing, and life cycle considerations. Application of design tools such as CAD, CAM, and FEM. Design methodologies, project scheduling, cost estimating, quality control, manufacturing processes. Development of a prototype and appropriate documentation in the form of written reports, oral presentations and computer models and engineering drawings.

E E 467: Multidisciplinary Engineering Design II  
Prereq: Student must be within two semesters of graduation or receive permission of instructor.  
Build and test of a conceptual design. Detail design, manufacturability, test criteria and procedures. Application of design tools such as CAD and CAM and manufacturing techniques such as rapid prototyping. Development and testing of a full-scale prototype with appropriate documentation in the form of design journals, written reports, oral presentations and computer models and engineering drawings.

E E 475: Automatic Control Systems  
(3-0) Cr. 3. F.  
Prereq: E E 324  
Stability and performance analysis of automatic control systems. The state space, root locus, and frequency response methods for control systems design. PID control and lead-lag compensation. Computer tools for control system analysis and design.

E E 476: Control System Simulation  
(2-3) Cr. 3. S.  
Prereq: E E 475  
Computer aided techniques for feedback control system design, simulation, and implementation.

E E 488: Eddy Current Nondestructive Evaluation  
(Dual-listed with E E 588). (Cross-listed with MAT E). (3-0) Cr. 3. Alt. F., offered odd-numbered years.  
Prereq: MATH 265 and (MAT E 216 or MAT E 273 or MAT E 392 or E E 311 or PHYS 364)  
Electromagnetic fields of various eddy current probes. Probe field interaction with conductors, cracks and other material defects. Ferromagnetic materials. Layered conductors. Elementary inversion of probe signals to characterize defects. Special techniques including remote-field, transient, potential drop nondestructive evaluation and the use of Hall sensors. Practical assignments using a 'virtual' eddy current instrument will demonstrate key concepts.

E E 489: Survey of Remote Sensing Technologies  
(Dual-listed with E E 589). (Cross-listed with GEOL, MTEOR, NREM). (3-0) Cr. 3. F.  
Prereq: Four courses in physical or biological sciences or engineering  
Electromagnetic-radiation principles, active and passive sensors, multispectral and hyperspectral sensors, imaging radar, SAR, thermal imaging, lidar. Examples of applications. Also offered online S.

E E 489L: Satellite Remote Sensing Laboratory  
(Dual-listed with E E 589L). (Cross-listed with GEOL, MTEOR, NREM). (0-3) Cr. 1. F.  
Prereq: Completion or concurrent enrollment in MTEOR/GEOL/NREM/EE 489/589  
Processing and analysis of satellite sensor data (optical and radar). Provides practical applications in an environmental context.

E E 490: Independent Study  
Cr. arr. Repeatable.  
Prereq: Senior classification in electrical engineering  
Investigation of an approved topic commensurate with the student's prerequisites.
E E 490H: Independent Study: Honors
Cr. arr.
Prereq: Senior classification in electrical engineering
Investigation of an approved topic commensurate with the student's prerequisites.

E E 491: Senior Design Project I and Professionalism
(Cross-listed with CPR E). (2-3) Cr. 3. F.S.
Prereq: E E 322 or CPR E 308, completion of 24 credits in the E E core professional program or 29 credits in the CPR E core professional program, ENGL 314
Preparing for entry to the workplace. Selected professional topics. Use of technical writing skills in developing project plan and design report; design review presentation. First of two-semester team-oriented, project design and implementation experience.

E E 492: Senior Design Project II
(Cross-listed with CPR E). (1-3) Cr. 2. F.S.
Prereq: CPR E 491 or E E 491
Second semester of a team design project experience. Emphasis on the successful implementation and demonstration of the design completed in E E 491 or CPR E 491 and the evaluation of project results. Technical writing of final project report; oral presentation of project achievements; project poster.

E E 494: Portfolio Assessment
(Cross-listed with CPR E). Cr. R.
Prereq: CPR E 394 or E E 394, credit or enrollment in CPR E 491 or E E 491
Portfolio update and evaluation. Portfolios as a tool to enhance career opportunities.

E E 496: Modern Optics
(Cross-listed with PHYS). (3-0) Cr. 3. S.
Prereq: Credit or enrollment in PHYS 322, PHYS 365, and PHYS 480
Review of wave and electromagnetic theory; topics selected from: reflection/refraction, interference, geometrical optics, Fourier analysis, dispersion, coherence, Fraunhofer and Fresnel diffraction, holography, quantum optics, nonlinear optics.

Courses primarily for graduate students, open to qualified undergraduates:

E E 501: Analog and Mixed-Signal VLSI Circuit Design Techniques
(Cross-listed with CPR E). (3-3) Cr. 4. F.
Prereq: E E 435

E E 504: Power Management for VLSI Systems
(Cross-listed with CPR E). (3-3) Cr. 4.
Prereq: E E 435, Credit or Registration for E E 501
Theory, design and applications of power management and regulation circuits (Linear and switching regulators, battery chargers, and reference circuits) including: Architectures, Performance metrics and characterization, Noise and stability analysis, Practical implementation and on-chip integration issues, design considerations for portable, wireless, and RF SoCs.

E E 505: CMOS and BiCMOS Data Conversion Circuits
(Cross-listed with CPR E). (3-3) Cr. 4. Alt. S., offered even-numbered years.
Prereq: E E 435 or E E 501
Theory, design and applications of data conversion circuits (A/D and D/A converters) including: architectures, characterization, quantization effects, conversion algorithms, spectral performance, element matching, design for yield, and practical comparators, implementation issues.

E E 506: Design of CMOS Phase-Locked Loops
(Cross-listed with CPR E). (3-3) Cr. 4.
Prereq: E E 435 or E E 501 or instructor approval
Analysis and design of phase-locked loops implemented in modern CMOS processes including: architectures, performance metrics, and characterization; noise and stability analysis; and design issues of phase-frequency detectors, charge pumps, loop filters (passive and active), voltage controlled oscillators, and frequency dividers.

E E 507: VLSI Communication Circuits
(Cross-listed with CPR E). (3-3) Cr. 4. Alt. S., offered odd-numbered years.
Prereq: E E 435 or E E 501
Phase-locked loops, frequency synthesizers, clock and data recovery circuits, theory and implementation of adaptive filters, low-noise amplifiers, mixers, power amplifiers, transmitter and receiver architectures.
E E 508: Filter Design and Applications
(3-3) Cr. 4.
Prereq: E E 501

E E 509: Mixed-Signal IC Testing and Built In Self Test
(3-0) Cr. 3.
Prereq: E E 424 or equivalent and E E 435 or E E 501
Introduction to mixed-signal IC testing; measurement uncertainty and test validity; IEEE standard test algorithms; high performance test and built-in self test challenges; new mixed-signal test algorithms and techniques to reduce data acquisition to relax instrumentation requirements, to simplify test setup, to improve test validity, and/or to enable co-testing of heterogeneous functions.

E E 510: Topics in Electromagnetics
Cr. 1-3. Repeatable.
Prereq: E E 311

E E 511: Modern Optical Communications
(3-0) Cr. 3. S.
Prereq: E E 311

E E 512: Advanced Electromagnetic Field Theory I
(3-0) Cr. 3. F.
Prereq: E E 311

E E 513: Advanced Electromagnetic Field Theory II
(3-0) Cr. 3. S.
Prereq: E E 512

E E 514: Microwave Engineering
(Dual-listed with E E 414). (3-3) Cr. 4. F.
Prereq: E E 230, E E 311
Principles, analyses, and instrumentation used in the microwave portion of the electromagnetic spectrum. Wave theory in relation to circuit parameters. S parameters, couplers, discontinuities, and microwave device equivalent circuits. RF amplifier design, microwave sources, optimum noise figure and maximum power designs. Microwave filters and oscillators.

E E 516: Computational Methods in Electromagnetics
(3-0) Cr. 3. S.
Prereq: E E 311

E E 517: Electromagnetic Radiation, Antennas, and Propagation
(Dual-listed with E E 417). (3-3) Cr. 4. S.
Prereq: E E 311

E E 518: Microwave Remote Sensing
(Cross-listed with AGRON, MTEOR). (3-0) Cr. 3. Alt. S., offered even-numbered years.
Prereq: Math 265 or equivalent
Microwave remote sensing of Earth's surface and atmosphere using satellite-based or ground-based instruments. Specific examples include remote sensing of atmospheric temperature and water vapor, precipitation, ocean salinity, and soil moisture.

E E 519: Magnetism and Magnetic Materials
(Dual-listed with E E 419). (Cross-listed with M S E). (3-0) Cr. 3. F.
Prereq: E E 311 or MAT E 317 or PHYS 364
E E 520: Selected Topics in Communications and Signal Processing
(3-0) Cr. 3. Repeatable.

E E 521: Advanced Communications
(3-0) Cr. 3. F.
Prereq: E E 422, credit or enrollment in E E 523

E E 522: Cognitive Radio Networks
(Cross-listed with CPR E). (3-0) Cr. 3. Alt. F., offered irregularly.
Prereq: Permission of instructor
Topics on cognitive radio networks: Cognitive Radio Networks Architecture; Software Defined Radio Architecture; Spectrum Sensing; Spectrum Management; Spectrum Sharing; Spectrum Mobility; Applications of Cognitive Radio Networks.

E E 523: Random Processes for Communications and Signal Processing
(3-0) Cr. 3.
Prereq: E E 322, MATH 317
Axioms of probability; Repeated trials; Functions of a random variable and multiple random variables: covariance matrix, conditional distribution, joint distribution, moments, and joint moment generating function; Mean square estimation; stochastic convergence; Some important stochastic processes: Random walk, Poisson, Wiener, and shot noise; Markov chains; Power spectral analysis; Selected applications.

E E 524: Digital Signal Processing
(3-0) Cr. 3. F.
Prereq: E E 322, E E 424, MATH 317

E E 527: Detection and Estimation Theory
(3-0) Cr. 3. S.
Prereq: E E 422

E E 528: Digital Image Processing
(3-0) Cr. 3. S.
Prereq: E E 322, E E 424
Review of sampling, linear algebra and probability. Classical image processing topics such as image sampling and quantization, image transforms (2D Fourier, KLT, DCT, etc), image enhancement, restoration and filtering. Image analysis topics including edge detection, segmentation, registration and tracking (uses least squares estimation, EM, Kalman filter). Medical image reconstruction from tomographic projections (Radon transform, Fourier slice theorem and reconstruction algorithms using them) and Magnetic Resonance Imaging (MRI). Basic introduction to image and video compression methods.

E E 529: Data Analytics in Electrical and Computer Engineering
(Cross-listed with CPR E). (3-0) Cr. 3. S.
Prereq: E E 322 or equivalent
Introduces a variety of data analytics techniques # particularly those relevant for electrical and computer engineers # from a foundational perspective. Topics to be covered include techniques for classification, visualization, and parameter estimation, with applications to signals, images, matrices, and graphs. Emphasis will be placed on rigorous analysis as well as principled design of such techniques.

E E 530: Selected Topics in Electronics, Microelectronics and Photonics
(3-0) Cr. 3. Repeatable.
Prereq: E E 332

E E 532: Microelectronics Fabrication Techniques
(Dual-listed with E E 432). (Cross-listed with M S E). (2-4) Cr. 4.
Prereq: credit or enrollment in E E 332
Techniques used in modern integrated circuit fabrication, including diffusion, oxidation, ion implantation, lithography, evaporation, sputtering, chemical-vapor deposition, and etching. Process integration. Process evaluation and final device testing. Extensive laboratory exercises utilizing fabrication methods to build electronic devices. Use of computer simulation tools for predicting processing outcomes. Recent advances in processing CMOS ICs and micro-electro-mechanical systems (MEMS).

E E 535: Physics of Semiconductors
(Cross-listed with PHYS). (3-3) Cr. 4.
Prereq: E E 311 and E E 332
Basic elements of quantum theory, Fermi statistics, motion of electrons in periodic structures, crystal structure, energy bands, equilibrium carrier concentration and doping, excess carriers and recombination, carrier transport at low and high fields, space charge limited current, photo-conductivity in solids, phonons, optical properties, amorphous semiconductors, heterostructures, and surface effects. Laboratory experiments on optical properties, carrier lifetimes, mobility, defect density, doping density, photo-conductivity, diffusion length of carriers.
E E 536: Physics of Semiconductor Devices  
(Cross-listed with PHYS). (3-0) Cr. 3.  
**Prereq:** E E 535  
P-n junctions, band-bending theory, tunneling phenomena, Schottky barriers, heterojunctions, bipolar transistors, field-effect transistors, negative-resistance devices and optoelectronic devices.

E E 538: Optoelectronic Devices and Applications  
(Dual-listed with E E 438). (3-0) Cr. 3.  
**Prereq:** E E 311, E E 332  

E E 547: Pattern Recognition  
(3-0) Cr. 3. F.  
**Prereq:** E E 324  

E E 552: Energy System Planning  
(3-0) Cr. 3.  
**Prereq:** E E 456, E E 457 or equivalent  

E E 553: Steady State Analysis  
(3-0) Cr. 3. F.  
**Prereq:** E E 456, E E 457  
Power flow, economic dispatch, unit commitment, electricity markets, automatic generation control, sparse matrix techniques, interconnected operation, voltage control.

E E 554: Power System Dynamics  
(3-0) Cr. 3. S.  
**Prereq:** E E 456, E E 457, E E 475  
Dynamic performance of power systems with emphasis on stability. Modeling of system components and control equipment. Analysis of the dynamic behavior of the system in response to small and large disturbances.

E E 555: Advanced Energy Distribution Systems  
(3-0) Cr. 3.  
**Prereq:** E E 455  
Transient models of distribution components, automated system planning and distribution automation, surge protection, reliability, power quality, power electronics and intelligent systems applications.

E E 556: Power Electronic Systems  
(3-0) Cr. 3.  
**Prereq:** E E 452  
Converter topologies, AC/DC, DC/DC, DC/AC, AC/AC. Converter applications to do motor drives, power supplies, AC motor drives, power system utility applications (var compensators) and power quality.

E E 559: Electromechanical Wind Energy Conversion and Grid Integration  
(Dual-listed with E E 459). (3-0) Cr. 3.  
**Prereq:** Credit or enrollment in E E 452, E E 456  
Summary of industry status and expected growth; power extraction from the air stream; operation and modeling of electric machines, and power electronics topologies for wind energy conversion; analysis of machine-grid power electronic circuits, controller interface, and collector (distribution) networks; treatment of harmonics, flicker, over/under-voltages, filters, low-voltage ride-through, and reactive compensation; relaying; effects on transmission expansion, planning and grid operation and coordination including variability, frequency control, reserves, and electricity markets; overview of storage technologies and hybrid configurations.

E E 565: Systems Engineering and Analysis  
(Cross-listed with AER E, I E). (3-0) Cr. 3.  
**Prereq:** Coursework in basic statistics  
Introduction to organized multidisciplinary approach to designing and developing systems. Concepts, principles, and practice of systems engineering as applied to large integrated systems. Life-cycle costing, scheduling, risk management, functional analysis, conceptual and detail design, test, evaluation and systems engineering planning and organization. Not available for degrees in industrial engineering.

E E 566: Avionics Systems Engineering  
(Cross-listed with AER E). (3-0) Cr. 3. S.  
**Prereq:** E E 565  
Avionics functions. Applications of systems engineering principles to avionics. Top down design of avionics systems. Automated design tools.

E E 570: Systems Engineering Analysis and Design  
(3-0) Cr. 3.  
**Prereq:** E E 475, E E 577  
Selected topics in abstract algebra, linear algebra, real analysis, functional analysis, and optimization methods in electrical engineering.
E E 571: Introduction to Convex Optimization
(3-0) Cr. 3.
Introduction to convex optimization problems emerging in electrical engineering. Efficiently solving convex optimization problems with the use of interior point algorithms software. Review of linear algebra, convex functions, convex sets, convex optimization problems, duality, disciplined convex programming, applications to optimal filtering, estimation, control and resources allocations, sensor network, distributed systems.

E E 573: Random Signal Analysis and Kalman Filtering
(Cross-listed with AER E, M E). (3-0) Cr. 3. F.
Prereq: E E 324 or AER E 331 or M E 370 or M E 411 or MATH 341

E E 574: Optimal Control
(Cross-listed with AER E, M E). (3-0) Cr. 3. S.
Prereq: E E 577

E E 575: Introduction to Robust Control
(Cross-listed with AER E, M E). (3-0) Cr. 3.
Prereq: E E 577

E E 576: Digital Feedback Control Systems
(Cross-listed with AER E, M E). (3-0) Cr. 3.
Prereq: E E 475 or AER E 432 or M E 411 or MATH 415; and MATH 267

E E 577: Linear Systems
(Cross-listed with AER E, M E, MATH). (3-0) Cr. 3. F.
Prereq: E E 324 or AER E 331 or MATH 415; and MATH 207

E E 578: Nonlinear Systems
(Cross-listed with AER E, M E, MATH). (3-0) Cr. 3. S.
Prereq: E E 577

E E 588: Eddy Current Nondestructive Evaluation
(Dual-listed with E E 488). (Cross-listed with M S E). (3-0) Cr. 3. Alt. F., offered odd-numbered years.
Prereq: MATH 265 and (MAT E 216 or MAT E 273 or MAT E 392 or E E 311 or PHYS 364)
Electromagnetic fields of various eddy current probes. Probe field interaction with conductors, cracks and other material defects. Ferromagnetic materials. Layered conductors. Elementary inversion of probe signals to characterize defects. Special techniques including remote-field, transient, potential drop nondestructive evaluation and the use of Hall sensors. Practical assignments using a 'virtual' eddy current instrument will demonstrate key concepts.

E E 589: Survey of Remote Sensing Technologies
(Dual-listed with E E 489). (Cross-listed with GEOL, MTEOR, NREM). (3-0) Cr. 3. F.
Prereq: Four courses in physical or biological sciences or engineering
Electromagnetic-radiation principles, active and passive sensors, multispectral and hyperspectral sensors, imaging radar, SAR, thermal imaging, lidar. Examples of applications. Also offered online S.

E E 589L: Satellite Remote Sensing Laboratory
(Dual-listed with E E 489L). (Cross-listed with GEOL, MTEOR, NREM). (0-3) Cr. 1. F.
Prereq: Completion or concurrent enrollment in MTEOR/GEOL/NREM/EE 489/589
Processing and analysis of satellite sensor data (optical and radar). Provides practical applications in an environmental context.

E E 590: Special Topics
Cr. 1-6. Repeatable.
Formulation and solution of theoretical or practical problems in electrical engineering.
E E 590A: Special Topics: Electromagnetic Theory  
Cr. 1-6. Repeatable.  
Formulation and solution of theoretical or practical problems in electrical engineering.

E E 590B: Special Topics: Control Systems  
Cr. 1-6. Repeatable.  
Formulation and solution of theoretical or practical problems in electrical engineering.

E E 590C: Special Topics: Communication Systems  
Cr. 1-6. Repeatable.  
Formulation and solution of theoretical or practical problems in electrical engineering.

E E 590E: Special Topics: Computer Engineering  
Cr. 1-6. Repeatable.  
Formulation and solution of theoretical or practical problems in electrical engineering.

E E 590F: Special Topics: Electric Power  
Cr. 1-6. Repeatable.  
Formulation and solution of theoretical or practical problems in electrical engineering.

E E 590G: Special Topics: Electrical Materials  
Cr. 1-6. Repeatable.  
Formulation and solution of theoretical or practical problems in electrical engineering.

E E 590H: Special Topics: Electronic Devices and Circuits  
Cr. 1-6. Repeatable.  
Formulation and solution of theoretical or practical problems in electrical engineering.

E E 590I: Special Topics: Signal Processing  
Cr. 1-6. Repeatable.  
Formulation and solution of theoretical or practical problems in electrical engineering.

E E 591: Seminar in Electronics, Microelectronics, and Photonics  
Cr. 1-3. Repeatable.

E E 594: Seminar in Electric Power  
Cr. 1-3. Repeatable.

E E 596: Seminar in Control Systems  
Cr. 1-3. Repeatable.

E E 597: Seminar in Communications and Signal Processing  
Cr. 1. Repeatable.  
Offered on a satisfactory-fail basis only.

E E 599: Creative Component  
Cr. arr. Repeatable.

Courses for graduate students:

E E 621: Coding Theory  
(3-0) Cr. 3.  
Prereq: E E 521  

E E 622: Information Theory  
(3-0) Cr. 3.  
Prereq: E E 521, E E 523  
Information system overview. Entropy and mutual information. Data Compression and source encoding. Discrete memoryless channel capacity. Noisy channel coding theorem. Rate distortion theory. Waveform channels. Advanced topics in information theory.

E E 653: Advanced Topics in Electric Power System Engineering  
(3-0) Cr. 3. Repeatable.  
Prereq: Permission of instructor  
Advanced topics of current interest in electric power system engineering.

E E 674: Advanced Topics in Systems Engineering  
(3-0) Cr. 3. Repeatable.  
Prereq: Permission of instructor  
Advanced topics of current interest in the areas of control theory, stochastic processes, digital signal processing, and image processing.

E E 697: Engineering Internship  
(Cross-listed with CPR E). Cr. R. Repeatable.  
One semester and one summer maximum per academic year professional work period. Offered on a satisfactory-fail basis only.

E E 699: Research  
Cr. arr. Repeatable.