

# Course Catalog - Fall 2005

## Electrical and Computer Engineering

### 101 **Exploring Digital Info Tech** Credit: 3 hours.

Principles and processes for the development of information technologies: digital music, digital images, digital logic, data compression, error correction, information security, and communication networks. Laboratory for design of hardware and software, and experiments in audio and image processing. Intended for students outside the College of Engineering. Credit is not given to students enrolled in Electrical or Computer Engineering

*This course satisfies the General Education Criteria for a Physical Sciences course.*

### 110 **Intro Elec & Comp Engrg** Credit: 4 hours.

(ECE 110) Integrated introduction to selected fundamental concepts and principles in electrical and computer engineering: circuits, electromagnetics, communications, electronics, controls, and computing. Laboratory experiments and lectures focus on a design and construction project, such as an autonomous moving vehicle.

Prerequisite: Credit or registration in either MATH 220 or MATH 235.

### 190 **Intro to Computing Systems** Credit: 4 hours.

Bits, binary representations, digital logic structures, the von Neumann computing model, an example instruction set, machine and assembly language programming, machine-level input/output, subroutines, the C programming language, variables and operators, control constructs, functions in C, pointers and arrays, input/output in C, recursion, simple data. Credit is not given for both ECE 190 and CS 125.

### 199 **Undergraduate Open Seminar** Credit: 1 to 5 hours.

(ECE 199) May be repeated. Approved for both letter and S/U grading.

### 200 **Seminar** Credit: 0 hours.

(ECE 200) Discussions of educational programs, career opportunities, and other topics in electrical and computer engineering For ECE students. Approved for S/U grading only.

### 205 **Intro Elec & Electr Circuits** Credit: 3 hours.

(ECE 205) Basic principles of circuit analysis, transient analysis, AC steady-state analysis, introduction to semiconductor devices and fabrication, digital logic circuits, op-amps, and A/D and D/A conversion. ECE students may not receive credit for this course. Prerequisite: PHYS 212.

### 206 **Intro Elec & Electr Ckts Lab** Credit: 1 hours.

(ECE 206) Laboratory instruments and basic measurement techniques, electric circuits, CMOS logic circuits, DTL and TTL circuits, and op-amps. ECE students may not receive credit for this course. Prerequisite: PHYS 212; concurrent registration in ECE 205.

### 210 **Analog Signal Processing** Credit: 4 hours.

(ECE 210) Introduction to analog signal processing, with an emphasis on underlying concepts from circuit and system analysis: linear systems, review of elementary circuit analysis, differential equation models of linear circuits and systems, Laplace transform, convolution, stability, phasors, frequency response, Fourier series, Fourier transform, active filters and AM radio. Prerequisite: ECE 110 and PHYS 212; credit or concurrent registration in MATH 385, MATH 386, or MATH 441.

### 211 **Topics Analog Ckts & Systems** Credit: 2 hours.

(ECE 211) Introduction to concepts from circuit and system analysis: linear systems, review of elementary circuit analysis, op amps, transient analysis, differential equation models of linear circuits and systems, Laplace transform. Students may not receive credit for both ECE 211 and ECE 210. Prerequisite: ECE 110 and PHYS 212; credit or concurrent registration in MATH 385, MATH 386, or MATH 441

### 280 **Biomedical Imaging** Credit: 3 hours.

(ECE 280) Introduction to the physics and engineering principles associated with magnetic resonance, ultrasound, computed tomography and nuclear imaging. Same as BIOE 280. Prerequisite: MATH 385, MATH 386, or MATH

441; PHYS 212; or consent of instructor.

**290 Computer Engineering, I** Credit: 3 hours.

Introduction to digital logic and computer systems. Representation of information, combinational network analysis and design, sequential network analysis and design, computer organization and control. Laboratory for design and simulation of digital systems. Credit is not given for both ECE 290 and CS 231. Prerequisite: One of CS 101, CS 125, ECE 110, ECE 190.

**307 Techniques for Engin Decisions** Credit: 3 hours.

The course is concerned with the modeling of decisions in engineering work and the analysis of models to develop a systematic approach to making decisions. The course aims to teach students to think structurally about decision-making problems. Fundamental concepts in linear and dynamic programming, probability theory and statistics serve as the mathematical basis for the development of techniques for solving typical problems faced in making engineering decisions in industry and government. Topics include resource allocation, logistics, scheduling, sequential decision making, siting of facilities, investment decisions, application of financial derivatives and other problems for decision making under uncertainty. Extensive use of case studies from actual industrial applications gets students involved in real-world decisions. Prerequisite: ECE 210; credit or concurrent registration in ECE 413 or equivalent.

**316 Engineering Ethics** Credit: 3 hours.

Ethical issues in the practice of engineering: safety and liability, professional responsibility to clients and employers, whistle-blowing, codes of ethics, career choice, legal obligations; case studies. Same as PHIL 316. Prerequisite: Junior standing; RHET 105.

*This course satisfies the General Education Criteria for a*Advanced Composition, and Hist&Philosoph Perspect course.

**317 Intro ECE Tech & Management** Credit: 3 hours.

The goal of this course is to equip non-engineering business-oriented students with the technical skills to become competitive as businesspersons in a technology-driven market. To accomplish this goal, this course will aim to provide a basic understanding of electrical and computer engineering concepts. An incomplete list of topics includes: basic circuit components, dc fundamentals, ac fundamentals, semiconductors, operational amplifiers, device fabrication, power distribution, digital devices, and computer architecture (including microprocessors). A relatively low level of mathematical ability (first term calculus) is assumed. This course is designed for the Business Majors in the Technology and Management program. Credit is not given to students enrolled in Electrical or Computer Engineering. Prerequisite: MATH 220 or MATH 234 or consent of instructor

**328 Comp Soln EM Probs, I** Credit: 1 hours.

(ECE 230) Solution of selected electromagnetics problems at the ECE 329 level using personal computers. Prerequisite: Credit or concurrent registration in ECE 329.

**329 Intro Electromagnetic Fields** Credit: 3 hours.

(ECE 229) Elementary electromagnetic field theory as summarized in Maxwell's equations for time-varying fields in integral and differential forms; energy storage; static and quasistatic fields; and time-domain analysis of waves. Prerequisite: ECE 205 or ECE 210

**385 Digital Systems Laboratory** Credit: 2 hours.

(ECE 249) Introduction to the experimental analysis and synthesis of digital networks, including the use of a microcomputer as a controller. Prerequisite: ECE 110 and ECE 290.

**390 Computer Engineering, II** Credit: 3 hours.

(ECE 291) Design and development of assembly language programs; input-output, interrupts, multitasking; introduction to data structures and graphics; ethical and social issues in computing; laboratory assignments on real-time data acquisition and device control. Credit is not given for both ECE 390 and CS 232. Prerequisite: ECE 290 or CS 231.

**395 Adv Digital Projects Lab** Credit: 2 to 3 hours.

(ECE 246) Planning, designing, executing, and documenting a microcomputer based project. Hardware is emphasized but the special projects required of student may also require an equal emphasis on software.

Prerequisite: ECE 385 or consent of instructor.

**396 Honors Project** Credit: 1 to 4 hours.

(ECE 296) Special project or reading course for James Scholars in engineering. Prerequisite: James Scholar in engineering; consent of instructor.

**397 Individual Study in ECE** Credit: 0 to 4 hours.

(ECE 272) Prerequisite: Approved written application to department as specified by department or instructor

**398 Special Topics in ECE** Credit: 0 to 4 hours.

(ECE 271) Prerequisite: As specified for each topic offering; see Schedule or departmental course information.

**399 Honors Seminar** Credit: 1 to 4 hours.

(ECE 297) Special lecture sequences and/or discussion groups arranged each term to bring James Scholars in engineering into direct contact with the various aspects of engineering practices and philosophy. Prerequisite: James Scholar in engineering; consent of instructor.

**402 Electronic Music Synthesis** Credit: 3 hours.

Historical survey of electronic and computer music technology; parameters of musical expression and their codification; analysis and synthesis of fixed sound spectra; time-variant spectrum analysis/synthesis of musical sounds; algorithms for dynamic sound synthesis. Prerequisite: MUS 103 or equivalent; ECE 290; ECE 410.

**403 Audio Engineering** Credit: 3 hours.

Review of resonance and wave phenomena; acoustics of rooms and auditoriums; artificial reverberation and sound localization/spatialization; loudspeakers, enclosures, and microphones; and topics in digital audio. Prerequisite: ECE 290, ECE 410, and ECE 473; or consent of instructor

**410 Digital Signal Processing, I** Credit: 4 hours.

Introduction to discrete-time systems and digital signal processing: discrete-time linear systems, difference equations, z-transform, discrete convolution, stability, discrete-time Fourier transform, analog-to-digital and digital-to-analog conversion, interpolation and decimation, digital filter design, discrete Fourier transform, fast Fourier transform, spectral analysis, applications of digital signal processing. Prerequisite: ECE 210 or consent of instructor

**411 Comp Organization & Design** Credit: 4 hours.

Basic computer organization and design, computer arithmetic, control design and microprogramming, memory organization, I/D design, reliability/performance evaluation; laboratory for computer design implementation, simulation, and layout. Credit is not given toward graduate degrees in Electrical Engineering. Prerequisite: ECE 390 or CS 232.

**412 Microcomputer Laboratory** Credit: 3 hours.

Design, construction, and use of a small general purpose computer with a micro-processor CPU; MSI and LSI circuits used extensively; control panel, peripheral controllers, control logic, central processor, and programming experiments; and open lab format. Prerequisite: ECE 385; ECE 390 or CS 232. Recommended: credit or concurrent registration in ECE 411.

**413 Probability with Engrg Applic** Credit: 3 hours.

Introduction to probability theory with applications to engineering problems such as the reliability of circuits and systems and to statistical methods for hypothesis testing, decision making under uncertainty, and parameter estimation. Credit is not given toward graduate degrees in Electrical Engineering. Prerequisite: ECE 210.

**414 Biomedical Instrumentation** Credit: 3 hours.

Introduction to engineering aspects of the detection, acquisition, processing, and display of signals from living systems; biomedical transducers for measurements of biopotentials, ions and gases in aqueous solution, force, displacement, blood pressure, blood flow, heart sounds, respiration, and temperature; and therapeutic and prosthetic devices. Same as BIOE 414. Prerequisite: ECE 205 or ECE 210 or consent of instructor.

**415 Biomedical Instrumentation Lab** Credit: 2 hours.

(ECE 315) Laboratory to accompany ECE 414. Studies medical instrumentation and transducers for static and dynamic nonbiological inputs and measures actual biomedical signals; requires some animal experiments. Same as BIOE 415. Prerequisite: Credit or concurrent registration in ECE 414.

**418 Image & Video Processing** Credit: 4 hours.

(ECE 318) Basic concepts and applications in image and video processing; introduction to multidimensional signal processing: sampling, Fourier transform, filtering, interpolation and decimation; human visual perception; scanning and display of images and video; image enhancement, restoration and segmentation; digital image and video compression; and image analysis. Laboratory exercises allow students to gain hands-on experience with these topics and develop C and Matlab programs. Prerequisite: ECE 410; credit or concurrent registration in one of ECE 413, STAT 400, IE 300, MATH 415, MATH 461; experience with C programming language.

**420 Digital Signal Processing Lab** Credit: 2 hours.

(ECE 320) Development of real-time digital signal processing (DSP) systems using a DSP microprocessor; several structured laboratory exercises, such as sampling and digital filtering, followed by an extensive DSP project of the student's choice. Prerequisite: ECE 410.

**421 Plasma and Fusion Science** Credit: 3 hours.

(ECE 321) Same as NPRE 421 and PHYS 479. See NPRE 421.

**425 Intro VLSI System Design** Credit: 3 hours.

(ECE 325) Complementary Metal-Oxide Semiconductor (CMOS) technology and theory; CMOS circuit and logic design; layout rules and techniques; circuit characterization and performance estimation; CMOS subsystem design; Very-Large-Scale Integrated (VLSI) systems design methods; VLSI Computer Aided Design (CAD) tools; laboratory experience in custom VLSI chip design on workstations using concepts of cell hierarchy; final project involving specification, design and evaluation of a VLSI chip or VLSI CAD program; and written report and oral presentation on the final project. Same as CS 435 and CSE 433. Prerequisite: ECE 385 and ECE 411; or CS 232.

**428 Distributed Systems** Credit: 3 hours.

(ECE 328) Same as CS 425 and CSE 424. See CS 425.

**430 Power Ckts & Electromechanics** Credit: 3 hours.

(ECE 330) Network equivalents, power and energy fundamentals, resonance, mutual inductance, three-phase power concepts, forces and torques of electric origin in electromagnetic and electrostatic systems, energy conversion cycles, principles of electric machines, transducers, relays, laboratory demonstration. Credit is not given toward graduate degrees in Electrical Engineering. Prerequisite: ECE 210.

**431 Electric Machinery** Credit: 4 hours.

(ECE 333) Theory and laboratory experimentation with three-phase power, power factor correction, single- and three- phase transformers, induction machines, DC machines, and synchronous machines; includes project work on energy control systems; digital simulation of machine dynamics. Prerequisite: ECE 430.

**432 Advanced Electric Machinery** Credit: 3 hours.

(ECE 336) Advanced rotating machine theory and practice, dynamic analysis of machines using reference frame transformations, tests for parameter determination, reduced order modeling of machines; mechanical subsystems including governors, prime movers, excitation systems, digital simulation of inter-connected machines. Prerequisite: ECE 431

**435 Computer Networking Laboratory** Credit: 3 to 4 hours.

Design, apply, analyze and evaluate communication network protocols under both Linux and Window NT operating systems. Emphasis on identifying problems, proposing alternative solutions, implementing prototypes using available network protocols and evaluating results. Students work in pairs on multiple programming projects per term. 3 undergraduate hours; or 3 to 4 graduate hours. Graduate students may receive 4 graduate hours by performing independent design projects. Prerequisite: CS 438.

**437 Sensors and Instrumentation** Credit: 3 hours.

This course gives senior and graduate students in ECE a hands-on introduction to the fundamental technology and practical application of sensors. Capacitive, inductive, optical, electromagnetic, and other sensing methods are examined. Instrumentation techniques incorporating computer control, sampling, and data collection and analysis are reviewed in the context of real-world scenarios. Prerequisite: ECE 329.

**438 Communication Networks** Credit: 3 hours.

Same as CS 438 and CSE 425. See CS 438.

**440 Solid State Electronic Devices** Credit: 3 hours.

Semiconductor materials and their electronic properties and applications to electronic devices; p-n junctions; transistors; junction field effect transistors and MOS devices; and introduction to integrated circuits. Credit is not given toward graduate degrees in Electrical Engineering. Prerequisite: PHYS 214; credit or concurrent registration in ECE 329.

**441 Physcs & Modeling Semicond Dev** Credit: 3 hours.

Detailed presentation of advanced concepts such as generation-recombination, hot electron effects, and breakdown mechanisms; essential features of small ac characteristics, switching and transient behavior of p-n junctions, bipolar and MOS transistors; addresses fundamental issues for device modeling and discusses the perspective and limitations of Si-devices. Prerequisite: ECE 440.

**442 Electronic Circuits** Credit: 3 hours.

(ECE 342) Analysis and design of analog and digital electronic circuits using MOS field effect transistors and bipolar junction transistors, with an emphasis on the study of amplifiers in integrated circuits. Credit is not given toward graduate degrees in Electrical Engineering. Credit is not given for both ECE 442 and PHYS 404. Prerequisite: ECE 210 and ECE 440.

**443 Electronic Circuits Laboratory** Credit: 1 hours.

(ECE 343) Laboratory to accompany ECE 442. Credit is not given toward graduate degrees in Electrical Engineering. Credit is not given for both ECE 443 and PHYS 404. Prerequisite: Concurrent registration in ECE 442.

**444 IC Device Theory & Fabrication** Credit: 4 hours.

(ECE 344) Laboratory and lecture course on the physical theory, design, and fabrication of devices suitable for integrated circuitry; includes the electrical properties of semiconductors and techniques (epitaxial growth, oxidation, photolithography diffusion, ion implantation, metallization, characterization) for fabricating integrated circuit devices such as p-n junction diodes, bipolar transistors, and field effect transistors. Prerequisite: ECE 440.

**445 Senior Design Project Lab** Credit: 2 hours.

(ECE 345) Individual design projects in various areas of electrical and computer engineering; projects are chosen by students with approval of the instructor; a written report, prepared to journal publication standards, and an oral presentation are required. Credit is not given toward graduate degrees in Electrical Engineering. Prerequisite: Senior standing in ECE.

**447 Active Microwave Ckt Design** Credit: 3 hours.

(ECE 347) Laboratory and lecture course on microwave circuit design of amplifiers, oscillators, and mixers. Prerequisite: ECE 450 and ECE 453.

**448 Intro Artificial Intelligence** Credit: 3 or 4 hours.

(ECE 348) Same as CS 440. See CS 440.

**449 Comp Soln EM Problems, II** Credit: 1 hours.

(ECE 349) Solution of selected electromagnetics problems at the ECE 450 level using personal computers. Credit is not given toward graduate degrees in Electrical Engineering. Prerequisite: ECE 328; credit or concurrent registration in ECE 450; or consent of instructor.

**450 Lines, Fields, and Waves** Credit: 3 hours.

(ECE 350) General plane wave solution of Maxwell's equations; reflection and transmission of plane waves; transmission lines; impedance matching; waveguides and cavities; and radiation. Credit is not given toward graduate degrees in Electrical Engineering. Prerequisite: ECE 329.

**451 Adv Microwave Measurements** Credit: 3 hours.

(ECE 351) Manual and computer controlled laboratory analysis of circuits at microwave frequencies. Prerequisite: ECE 450.

**452 Electromagnetic Fields** Credit: 3 hours.

(ECE 352) Plane waves at oblique incidence, wave polarization, anisotropic media, radiation, space communications, and waveguides. Prerequisite: ECE 450

**453 Radio Communication Circuits** Credit: 4 hours.

(ECE 353) Design of a radio system for transmission of information; types of receivers, matching techniques, receiver and antenna noise, types of modulation, high-frequency circuitry, and point-to-point and satellite communications. Prerequisite: ECE 442; credit or concurrent registration in ECE 450

**454 Antennas** Credit: 3 hours.

(ECE 354) Antenna parameters; polarization of electromagnetic waves; basic antenna types; antenna arrays; broadband antenna design; and antenna measurements. Prerequisite: ECE 450 or consent of instructor

**455 Optical Electronics** Credit: 3 or 4 hours.

(ECE 355) Optical beams and cavities; semiclassical theory of gain; characteristics of typical lasers (gas, solid state, and semiconductor); and application of optical devices. 3 undergraduate hours. 4 graduate hours. Prerequisite: ECE 450 or PHYS 436 or consent of instructor.

**457 Microwave Devices & Circuits** Credit: 3 hours.

(ECE 357) Electromagnetic wave propagation, microwave transmission systems, passive components, microwave tubes, solid state microwave devices, microwave integrated circuits, S-parameter analysis, microstrip transmission lines. Prerequisite: ECE 440 or equivalent; ECE 450 or equivalent.

**458 Applic of Rad Wave Propagation** Credit: 3 hours.

(ECE 358) Terrestrial atmosphere, radio wave propagation, and applications to radio sensing and radio communication. Prerequisite: ECE 450 or consent of instructor

**459 Communications, I** Credit: 3 hours.

(ECE 359) Introduction to analog and digital modulation techniques, random processes, and power spectral density. Effects of noise on, and bandwidth requirements of, different modulation schemes. Prerequisite: ECE 413 or equivalent

**460 Optical Imaging** Credit: 3 hours.

(ECE 360) Introduction to visible and infrared imaging systems covering fields, optical elements, electronic sensors, and embedded processing systems. Lectures and labs cover active and passive illumination, ranging, holography, polarization, coherence, spectroscopy and sampling with an emphasis on electronic optomechanical control and data acquisition. Prerequisite: ECE 329; credit or concurrent registration in ECE 413 or STAT 400.

**461 Communications, II** Credit: 3 hours.

(ECE 361) Digital communication systems, modulation, demodulation, channel models, bit error rate, spectral occupancy, synchronization, equalization, and trellis-coded modulation. Prerequisite: ECE 459

**462 Logic Design** Credit: 3 hours.

(ECE 362) Design of combinational networks, hazards, finite state testing machines, design of sequential networks in fundamental mode and pulse mode, state reduction, state assignment and races, and fault detection and testing. Same as CS 462 and MATH 491. Prerequisite: ECE 290 or CS 231

**463 Digital Communications Lab** Credit: 2 hours.

(ECE 363) The focus of this laboratory course is digital communications systems. Students will gain hands-on experience in the configuration and performance evaluation of digital communication systems employing both radio and optical signals. Prerequisite: ECE 459 or equivalent. Credit or concurrent registration in ECE 461 recommended

**464 Power Electronics** Credit: 3 hours.

(ECE 364) Switching functions and methods of control such as pulse-width modulation, phase control, and phase modulation; dc-dc, ac-dc, dc-ac, and ac-ac power converters; power components, including magnetic components and power semiconductor switching devices. Prerequisite: ECE 442

**465 Optical Communication Systems** Credit: 3 hours.

Fundamentals of lightwave systems: characterization of lightwave channels, optical transmitters, receivers and amplifiers; quantum and thermal noise processes; design of optical receivers; multimode and single-mode link analysis. Prerequisite: ECE 329, ECE 413, and ECE 450. Recommended: credit or concurrent registration in ECE 459 and ECE 466.

**466 Optical Communication Lab** Credit: 1 hours.

Laboratory course in optical communication systems: fiber components and measurements, transmitters and detectors, fiber amplifiers, multimode fiber links and wavelength division multiplexing. Prerequisite: Credit or concurrent registration in ECE 465.

**468 Optical Remote Sensing** Credit: 3 hours.

Introduction to Optical Remote Sensing. Optical sensors including single element and area arrays (CCDs). Systems including imager, spectrometer, interferometer and lidar optical principles and light gathering power. Electromagnetics of atomic and molecular emission and scattering with applications to the atmosphere as an example. Applications include ground and spacecraft platforms. Four laboratory sessions (4.5 hours each) will be arranged during the semester in lieu of four lectures. Same as AE 468 and ATMS 468. Prerequisite: PHYS 214, ECE 210, ECE 329, and a course in probability or statistics; or consent of instructor.

**469 Power Electronics Laboratory** Credit: 2 hours.

(ECE 369) Laboratory study of circuits and devices used for switching power converters, solid-state motor drives, and power controllers, including dc-dc, ac-dc, and dc-ac converters and applications; high-power transistors and magnetic components; design considerations, including heat transfer. Prerequisite: ECE 443 or consent of instructor; credit or concurrent registration in ECE464

**470 Introduction to Robotics** Credit: 4 hours.

(ECE 370) Fundamentals of robotics, rigid motions, homogeneous transformations, forward and inverse kinematics, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control. Same as CS 443, GE 421, and ME 445. Prerequisite: MATH 415 or 418; ECE 210 or GE 320; or consent of instructor.

**473 Fund of Engrg Acoustics** Credit: 3 or 4 hours.

(ECE 373) Development of the basic theoretical concepts of acoustical systems; mechanical vibration, plane and spherical wave phenomena in fluid media, lumped and distributed resonant systems, and absorption phenomena and hearing. Same as TAM 413. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: MATH 385 or equivalent.

**474 Ultrasonic Techniques** Credit: 3 or 4 hours.

(ECE 374) Ultrasonic wave propagation, generation, detection, and measurement in liquid and solid media, acoustic impedance concepts, ultrasonic absorption and velocity measurement techniques, piezoelectricity, and discussion of industrial, experimental, bioengineering, and medical applications. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: ECE 473 or equivalent or consent of instructor.

**475 Modeling of Bio-Systems** Credit: 3 or 4 hours.

(ECE 375) Application of linear systems theory and feedback control systems analysis to biological systems; sensory receptors, neuro-muscular system models, control of eye movement, the pupil control system, man-machine interactions, parameter identification in biological systems; and optional project laboratory. Same as BIOE 475. Prerequisite: GE 320 or ECE 210 or consent of instructor.

**476 Power System Analysis** Credit: 3 hours.

(ECE 376) Examines the development of power system equivalents, per phase network analysis, load flow, symmetrical components, sequence networks, fault analysis, and digital simulation. Prerequisite: ECE 430.

**477 Power Syst Operation & Control** Credit: 3 hours.

(ECE 378) Studies economic operation of power systems, system protection, power system stability, dynamics and control of power systems, high voltage DC transmission, load flow interface, digital simulation. Prerequisite: ECE 476

**478 Formal Software Dev Methods** Credit: 3 or 4 hours.

Same as CS 477. See CS 477.

**480 Magnetic Resonance Imaging** Credit: 3 or 4 hours.

(ECE 380) Fundamental physical, mathematical and computational principles governing the data acquisition and image reconstruction of magnetic resonance imaging. Same as BIOE 480. 3 undergraduate hours. 3 or 4 graduate hours. Approved for both letter and S/U grading. Prerequisite: ECE 410 recommended.

**482 Digital IC Design** Credit: 3 hours.

(ECE 382) Bipolar and MOS field effect transistor characteristics; VLSI fabrication techniques for MOS and bipolar circuits; calculation of circuit parameters from the process parameters; and design of VLSI circuits such as logic, memories, charge-coupled devices, and A/D and D/A converters. Prerequisite: ECE 290 and ECE 442

**483 Analog IC Design** Credit: 3 hours.

(ECE 383) Basic linear integrated circuit design techniques using bi-polar, JFET, and MOS technologies; operational amplifiers; wide-band feedback amplifiers; sinusoidal and relaxation oscillators; electric circuit noise; application of linear integrated circuits. Prerequisite: ECE 442.

**484 Prin Adv Microelec Processing** Credit: 3 hours.

(ECE 384) Teaches seniors and first year graduate students in Electrical Engineering advanced topics in semiconductor device processing. Covers the principles of advanced methods of pattern delineation, pattern transfer, modern material growth and how these are applied to produce novel and high performance devices and circuits in various semiconductor materials with special emphasis on compound semiconductors. Issues in computer simulation of processes and the manufacturing of devices and circuits are also covered. Prerequisite: ECE 444.

**485 Intro MEM Devices & Systems** Credit: 3 hours.

(ECE 385) Course presents an introduction to the principles, fabrication techniques, and applications of microelectromechanical systems (MEMS). Students will gain an in-depth understanding of sensors and actuator principles and integrated microfabrication techniques for MEMS. It also consists of a comprehensive investigation of the state-of-the-art MEMS devices and systems. Same as IE 485 and ME 485. Prerequisite: Senior standing in the College of Engineering.

**486 Control Systems** Credit: 4 hours.

(ECE 386) Analysis and design of control systems with emphasis on modeling, state variable representation, computer solutions, modern design principles, and laboratory techniques. Prerequisite: ECE 210 or consent of instructor.

**487 Intro Quantum Electr for EEs** Credit: 3 hours.

(ECE 387) Application of quantum mechanical concepts to electronics problems; detailed study of a calculable two-state laser system; and incidental quantum ideas bearing on electronics. Prerequisite: PHYS 485 or consent of instructor.

**488 Compound Semicond & Devices** Credit: 3 hours.

(ECE 388) Advanced semiconductor materials and devices course covering elementary band theory, heterostructures, transport issues, three-terminal devices, two-terminal devices, including lasers and light

modulators. Prerequisite: ECE 440; ECE 450 or consent of instructor

**489 Robot Dynamics and Control** Credit: 4 hours.  
(ECE 389) Same as GE 422 and ME 446. See GE 422.

**490 Introduction to Optimization** Credit: 3 or 4 hours.  
(ECE 390) Basic theory and methods for the solution of optimization problems; iterative techniques for unconstrained minimization; and introductory presentation of linear and nonlinear programming with engineering applications. Same as CSE 441. 3 undergraduate hours. 4 graduate hours. Prerequisite: CS 101 or CS 125; MATH 380; or consent of instructor.

**491 Intro to Numerical Analysis** Credit: 3 or 4 hours.  
(ECE 391) Same as CS 450, CSE 401, and MATH 450. See CS 450.

**492 Intro to Parallel Programming** Credit: 3 or 4 hours.  
(ECE 392) Same as CS 420 and CSE 402. See CS 420.

**496 Proj & Lect in Quantum Electr** Credit: 3 hours.  
(ECE 397) Studies processes involving quantum mechanical energy transfers in energized media leading to various lasering devices and their applications. A series of lectures, supplementing the special projects, offers background information on spectroscopy, collisional energy transfer, laser pumping schemes, modulation at optical frequencies, holography, and other related topics. Prerequisite: Senior standing; consent of instructor; ECE 487 recommended.

**497 Senior Research Project** Credit: 2 hours.  
(ECE 298) Individual research project under the guidance of a faculty member: for example, mathematical analysis, laboratory experiments, computer simulations, software development, circuit design, or device fabrication. Preparation of a written research proposal, which includes preliminary results. 2 undergraduate hours. No graduate credit. Prerequisite: Senior standing; RHET 105; consent of instructor.  
*This course satisfies the General Education Criteria for a*Advanced Composition course.

**498 Special Topics in ECE** Credit: 0 to 4 hours.  
(ECE 371) Lectures and discussions relating to new areas of interest. May be repeated. Prerequisite: As specified for each topic offering; see Schedule or departmental course information.

**499 Senior Thesis** Credit: 2 hours.  
(ECE 299) Completion of the research project begun under ECE 497. Preparation and oral presentation of a written thesis that reports the results of the project. 2 undergraduate hours. Approved for both letter and S/U grading. No graduate credit. Prerequisite: ECE 497 and consent of instructor.  
*This course satisfies the General Education Criteria for a*Advanced Composition course.

**500 Graduate Seminar** Credit: 0 hours.  
(ECE 400) Required of all graduate students. Approved for S/U grading only.

**511 Computer Architecture** Credit: 4 hours.  
(ECE 412) Advanced concepts in computer architecture; design, management, and modeling of memory hierarchies, stack-oriented processors, associative processors, pipelined computers, and multiple processor systems; and focuses on hardware alternatives in detail and their relation to system performance/cost. Same as CSE 521. Prerequisite: ECE 411 or CS 433 or consent of instructor

**512 Computer Microarchitecture** Credit: 4 hours.  
(ECE 411) Design of high performance computer systems; instruction level concurrency; memory system implementation; pipelining, superscalar, and vector processing; compiler back-end code optimization; profile assisted code transformations; code generation and machine dependent code optimization; cache memory design for multiprocessors; synchronization implementation in multiprocessors; compatibility issues; technology factors; state-of-the-art commercial systems. Same as CSE 528. Prerequisite: ECE 511; CS 426 or equivalent.

**513 Signal & Spectral Analysis** Credit: 4 hours.

(ECE 413) Fundamentals of linear least squares estimation of discrete-time signals and their spectra; minimum-norm least squares and total least squares solutions; singular value decomposition; Wiener and Kalman filtering; autoregressive spectral analysis; and the maximum entropy method. Prerequisite: ECE 410, ECE 413, MATH 418 or equivalent; or consent of instructor

**515 Control Syst Theory & Design** Credit: 4 hours.

(ECE 415) Synthesis of feedback control systems to meet design specifications, including sensitivity; multivariable systems; introduction to systems with random inputs; state variable techniques; and nonlinear systems. Prerequisite: ECE 486 or equivalent; or consent of instructor

**517 Nonlinear & Adaptive Control** Credit: 4 hours.

(ECE 417) Studies design of nonlinear control systems based on stability considerations; examines Lyapunov and hyperstability approaches to analysis and design of model reference adaptive systems; identifiers, observers, and controllers for unknown plants. Prerequisite: ECE 515.

**520 EM Waves & Radiating Systems** Credit: 4 hours.

(ECE 420) Fundamental electromagnetic theory with applications to transmission lines, waveguides, and antennas; introduction to the solution of advanced problems in static electric and magnetic fields. Prerequisite: ECE 452.

**522 Controlled Fusion Systems, I** Credit: 4 hours.

(ECE 422) Same as NPPE 522. See NPPE 522.

**523 Gaseous Electronics & Plasmas** Credit: 4 hours.

(ECE 423) Basic concepts and techniques, both theoretical and experimental, which are used in the areas of gaseous electronics, gas and solid plasmas, controlled fusion, aeronomy, gas lasers, and magnetohydrodynamics. Prerequisite: PHYS 485 or ECE 452 or equivalent; or consent of instructor

**525 Nucl-Electr Energy Conversion** Credit: 4 hours.

(ECE 425) Same as NPPE 525. See NPPE 525.

**528 Analysis of Nonlinear Systems** Credit: 4 hours.

(ECE 428) First-level graduate course on the analysis on nonlinear dynamical systems, covering topics such as nonlinear dynamics, vector fields and flows, Lyapunov stability theory, regular and singular perturbations, averaging, integral manifolds, input-output and input-to-state stability, and various design applications in control systems and robotics. Same as GE 520, and ME 546. Prerequisite: ECE 515 or equivalent; one of MATH 385, MATH 386, MATH 441; or consent of instructor

**531 Theory of Guided Waves** Credit: 4 hours.

(ECE 431) Propagation of electromagnetic waves in general cylindrical waveguides; stationary principles; non-uniform inhomogeneously filled waveguides; mode and power orthogonality; losses in waveguides; analytical and numerical techniques; microwave integrated circuits waveguides; and optical waveguides. Prerequisite: ECE 520; MATH 556 recommended

**532 Compound Semiconductors** Credit: 4 hours.

(ECE 432) Properties of III-V and II-VI compound semiconductors and the devices which are unique to these materials; emphasis on materials such as GaAs, Ga(AsP), GaP, CdSe, Cd(SeS), etc., and on luminescence, semiconductor lamps, and semiconductor lasers. Prerequisite: Graduate standing in electrical engineering with some background in modern physics; elementary quantum mechanics; elementary semiconductor theory or equivalent

**533 Parallel Computer Architecture** Credit: 4 hours.

(ECE 433) Same as CS 533 and CSE 522. See CS 533.

**534 Random Processes** Credit: 4 hours.

(ECE 434) Basic concepts of random processes; linear systems with random inputs; Markov processes; spectral

analysis; Wiener and Kalman filtering; applications to systems engineering. Prerequisite: One of ECE 413, MATH 461, STAT 400; or consent of instructor

**535 Theory Semicond & Devices** Credit: 4 hours.

(ECE 435) Introductory quantum mechanics of semiconductors; energy bands; dynamics of Bloch electrons in static and high-frequency electric and magnetic fields; equilibrium statistics; transport theory, diffusion, drift and thermoelectric effects; and characteristics of p-n junctions, heterojunctions, and transistor devices. Same as PHYS 565. Prerequisite: Senior-level course in quantum mechanics or atomic physics

**536 Integ Optics & Optoelectronics** Credit: 4 hours.

(ECE 436) Integrated optical and optoelectronic devices; theory of optical devices including laser sources, waveguides, photodetectors, and modulations of these devices. Prerequisite: One of ECE 455, ECE 487, PHYS 486; ECE 488 recommended

**537 Speech Processing** Credit: 4 hours.

(ECE 437) Introduction to the theory and techniques in speech processing and recognition; includes speech production model, spectral analysis, pattern comparison techniques, hidden Markov models (HMM), and HMM-based automatic speech recognition; also includes computer laboratory. Prerequisite: ECE 410 and ECE 534; experience with C programming and UNIX systems

**539 Adv Theory Semicond & Devices** Credit: 4 hours.

(ECE 439) Selected advanced topics of current interest in the physics of semiconductors and solid-state devices. Same as CSE 534. Prerequisite: ECE 535.

**540 Computational Electromagnetics** Credit: 4 hours.

(ECE 440) Course will cover basic computational techniques for numerical analysis of electromagnetics problems, including the finite difference, finite element, and moment methods. Emphasis will be placed on the formulation of physical problems into mathematical boundary-value problems, numerical discretization of continuous problems into discrete problems, and development of rudimentary computer codes for simulation of electromagnetic fields in engineering problems using each of these techniques. Same as CSE 530. Prerequisite: ECE 520 or concurrent registration in ECE 520; CS 257 or equivalent; or consent of instructor.

**541 Computer Systems Analysis** Credit: 4 hours.

(ECE 441) Same as CS 541 and CSE 524. See CS 541.

**542 Design Fault-Tolerant Dig Syst** Credit: 4 hours.

(ECE 442) Advanced concepts in hardware and software fault tolerance; topics addressed include fault models, coding in computer systems, module and system level fault detection mechanism, reconfiguration techniques in multiprocessor systems and VLSI processor arrays, software fault tolerance techniques such as recovery blocks, N-version programming, checkpointing and recovery; survey of practical fault-tolerant systems. Same as CS 536. Prerequisite: ECE 411 or equivalent

**543 Dig Testing & Design for Test** Credit: 4 hours.

(ECE 443) Fundamental techniques of detecting failures in complex digital systems, algorithms for automatic test generation, schemes for designing systems to be easily testable and with self test capability; hands-on experience with state-of-the-art computer-aided test tools in the laboratory. Prerequisite: ECE 411; ECE 462 or equivalent

**545 Advanced Physical Acoustics** Credit: 4 hours.

(ECE 445) Advanced topics in acoustics including physical properties of a fluid; linear propagation phenomena; nonlinear phenomena such as radiation force, streaming, and harmonic generation; cavitation; and absorption and dispersion. Same as TAM 515. Prerequisite: One of ECE 473, ECE 520, TAM 518, or equivalent; or consent of instructor

**547 Topics in Image Processing** Credit: 4 hours.

(ECE 447) Examines fundamental concepts, techniques, and directions of research in image processing; topics include two-dimensional Fourier transform and filtering, image digitization, coding, restoration, reconstruction, analysis, and recognition. Same as CSE 543. Prerequisite: ECE 410 and ECE 413; or equivalent

**548 *Comp Models of Cognitive Proc*** Credit: 4 hours.  
(ECE 448) Same as CS 548. See CS 548.

**549 *Computer Vision*** Credit: 4 hours.

(ECE 449) Examines information processing approaches to computer vision, and algorithms and architectures for artificial intelligence and robotics systems capable of vision: inference of three-dimensional properties of a scene from its images, such as distance, orientation, motion, size and shape, acquisition and representation of spatial information for navigation and manipulation in robotics. Same as CS 543. Prerequisite: ECE 448 or CS 225 or consent of instructor

**550 *Advanced Robotic Planning*** Credit: 4 hours.

(ECE 450) Computational approaches to robot motion planning, configuration space, algebraic decompositions, artificial potential fields, retraction, approximate decompositions, planning under uncertainty, grasp planning and task-level planning. Approved for both letter and S/U grading. Prerequisite: CS 473 or equivalent; graduate standing

**551 *Digital Signal Processing II*** Credit: 4 hours.

(ECE 451) Reviews basic concepts of digital signals and systems; examines computer-aided digital filter design, quantization effects, decimation and interpolation, fast algorithms for convolution and the DFT; and introduces adaptive signal processing. Same as CSE 542. Prerequisite: ECE 410 and ECE 413; or equivalent

**552 *Numerical Circuit Analysis*** Credit: 4 hours.

(ECE 452) Formulation of circuit equations; sparse matrix algorithms for the solution of large systems, AC, DC, and transient analysis of electrical circuits; sensitivity analysis; decomposition methods. Same as CSE 532. Prerequisite: MATH 415 and ECE 210.

**553 *Optimum Control Systems*** Credit: 4 hours.

(ECE 453) Formulation of the optimization problem; controllability; observability; stability; Lyapunov's second method; application of variational calculus, maximum principle, and principle of optimality to control problems; stochastic control; and adaptive control. Prerequisite: ECE 515

**555 *Control of Stochastic Systems*** Credit: 4 hours.

(ECE 455) Stochastic control models; development of control laws by dynamic programming; separation of estimation and control; Kalman filtering; self-tuning regulators; dual controllers; decentralized control. Prerequisite: ECE 515 and ECE 534.

**556 *Coding Theory*** Credit: 4 hours.

(ECE 456) General discussion on coding theory with emphasis on the algebraic theory of cyclic codes using finite field arithmetic, decoding of BCH and RS codes, finite field Fourier transform and algebraic geometry codes, convolutional codes and trellis decoding algorithms. Same as CS 577 and MATH 579. Prerequisite: MATH 417 or equivalent or consent of instructor

**558 *Digital Imaging*** Credit: 4 hours.

(ECE 458) Multidimensional signals, convolution, transforms, sampling, and interpolation; design of two-dimensional digital filters; sensor array processing and range-doppler imaging; applications to synthetic aperture radar, optics, tomography, radio astronomy, and beam-forming sonar; image estimation from partial data. Prerequisite: ECE 410 and ECE 413; or equivalent

**559 *Topics in Communications*** Credit: 4 hours.

(ECE 459) Lectures and discussion related to advanced topics and new areas of interest in the theory of communication systems, including information theory, coding theory, and communication network theory. May be repeated in the same term as topics vary, to a maximum of 12 graduate hours; may be repeated in separate terms as topics vary, to a maximum of 16 graduate hours. Two or more sections of this course may be offered in a term with different outlines. Students registering in more than one section should receive credit separately for each section. Students will not receive additional credit toward a degree from multiple offerings of this course if those offerings have significant overlap, as determined by the Electrical and Computer Engineering department.

Prerequisite: Specified each semester or consent of instructor. (It is expected that each offering will have a 500-level course as a prerequisite or co-requisite)

**560 VLSI in DSP & Communication** Credit: 4 hours.

(ECE 460) Basic concepts in digital signal processing, VLSI design methodologies, VLSI DSP building blocks; algorithm transformation and mapping techniques, high-speed, low-power transforms, applications to digital filtering; basics of finite-field arithmetic, forward-error correction algorithms, and architectures; DSP implementation platforms, programmable DSPs, media processors, FPGAs, ASICs, case studies of multimedia communications systems, video codecs, xDSL and cable modems. Homework and a term project allow students to apply these concepts in the design of VLSI architectures for digital signal processing and communication systems. Prerequisite: ECE 410

**561 Detection & Estimation Theory** Credit: 4 hours.

(ECE 461) Introduction to detection and estimation theory, with applications to communication, control, and radar systems; decision-theory concepts and optimum-receiver principles; detection of random signals in noise, coherent and noncoherent detection; and parameter estimation, linear and nonlinear estimation, and filtering. Prerequisite: ECE 534 or equivalent or consent of instructor

**563 Information Theory** Credit: 4 hours.

(ECE 463) Mathematical models for channels and sources; entropy, information, data compression, channel capacity, Shannon's theorems, rate-distortion theory. Same as CS 578 and STAT 563. Prerequisite: MATH 466 or ECE 534 or consent of instructor

**567 Communication Network Analysis** Credit: 4 hours.

(ECE 467) First high-level course in performance analysis and design of multiple-user communication systems; emphasizes rigorous formulation and analytical and computational methods; includes queuing networks, decentralized minimum delay routing and dynamic network flow control. Prerequisite: CS 438; ECE 534 or MATH 466; or consent of instructor

**568 Model & Ctrl Electromech Syst** Credit: 4 hours.

(ECE 468) Examines fundamental electrical and mechanical laws for derivation of machine models; simplifying transformations of variables in electrical machines; power electronics for motor control; time-scale separation; feedback linearization and nonlinear control as applied to electrical machines. Typical electromechanical applications in actuators, robotics, and variable speed drives. Same as ME 565. Prerequisite: ECE 431 and ECE 515; or consent of instructor.

**569 Diffraction, Coherence & Info** Credit: 4 hours.

(ECE 469) Analysis of information encoding, transmission and decoding in spatially complex optical systems. Analysis of digital and analog imaging, holography, and interferometry. Analysis of physical and electronic transformations in imaging systems. Discussion of multiplex imaging and imaging transformations. Prerequisite: ECE 460 or consent of instructor

**570 Nonlinear Optics** Credit: 4 hours.

(ECE 470) Light propagation in anisotropic crystals; second- and third-order nonlinear susceptibility and electro-optic effect; and discussion of the relationship of these effects along with such applications as light modulation, harmonic generation, and optical parametric amplification and oscillation. Prerequisite: ECE 520

**571 EM Waves in Inhomogen Media** Credit: 4 hours.

(ECE 471) Electromagnetic waves in layered media; plane wave expansion of electromagnetic point source field; Sommerfeld integrals; transient response; WKB method with asymptotic matching; scattering by junction discontinuity; surface integral equation; volume integral equation; inverse problems. Prerequisite: MATH 446; ECE 520 or PHYS 505 or equivalent.

**572 Quantum Electronics** Credit: 4 hours.

(ECE 472) Brief theoretical introduction to quantum mechanics and atomic physics, with many applications in spin resonance and modern maser theory. Prerequisite: PHYS 485 recommended

**573 Power System Control** Credit: 4 hours.

(ECE 473) Studies energy control center functions, state estimation and steady state security assessment techniques, economic dispatch, optimal power flow, automatic generation control, and dynamic equivalents. Same as CSE 545. Prerequisite: ECE 476 or consent of instructor

**576 Power System Dyn & Stability** Credit: 4 hours.

(ECE 476) Detailed modeling of the synchronous machine and its controls, such as excitation system and turbine-governor dynamics; time-scales and reduced order models; non-linear and linear multi-machine models; stability analysis using energy functions; power system stabilizers. Same as CSE 544. Prerequisite: ECE 476 or consent of instructor. Concurrent registration in ECE 515 recommended

**577 Advanced Antenna Theory** Credit: 4 hours.

(ECE 477) Selected topics from recent engineering literature on antennas supplemented by advanced topics in electromagnetic theory needed for comprehension; current techniques for analysis of wire, slot, horn, frequency independent, quasi-optical, and array antennas. Prerequisite: ECE 520

**578 Adv EM Diffraction & Radiation** Credit: 4 hours.

(ECE 478) Asymptotic solutions of Maxwell's equations, geometrical optics, edge diffraction, uniform theories, creeping waves, advanced antenna theory, and topics of current interest. Prerequisite: ECE 520 or PHYS 505; ECE 577 recommended.

**579 Computational Complexity** Credit: 4 hours.

(ECE 479) Turing machines; determinism and non-determinism; time and space hierarchy theorems; speed-up and tape compression; Blum axioms; structure of complexity classes NP, P, NL, L, PSPACE; complete problems; randomness and complexity classes RP, RL, BPP; alternation, polynomial-time hierarchy; circuit complexity, parallel complexity, NC, RNC; relativized computational complexity; time-space trade-offs. Same as CS 579 and MATH 578. Prerequisite: CS 473 or CS 475 or consent of instructor

**580 Optimization by Vector Methods** Credit: 4 hours.

(ECE 480) Same as MATH 587. See MATH 587.

**582 Physical VLSI Design** Credit: 4 hours.

(ECE 482) Basic physical design requirements for VLSI; performance-oriented formulation and optimization of chip partitioning, module placement and interconnection; optimized design and layout of on-chip modules; circuit extraction; high-speed VLSI circuits; yield and reliability analysis; advanced VLSI packaging and parametric testing. Prerequisite: ECE 425 or ECE 482

**584 IC Reliability Engineering** Credit: 4 hours.

(ECE 484) Description of the algorithms and procedures required to study the reliability of integrated circuit products. Covers reliability modeling, physical causes of semiconductor device failure, reliability model development and calibration, model-based reliability prediction, product testing and measurement, and failure diagnosis. Coverage emphasizes application to integrated circuit technology. Prerequisite: ECE 413 and ECE 440; or consent of instructor

**585 MOS Device Modeling & Design** Credit: 4 hours.

(ECE 485) Techniques for characterizing gate oxide and interface properties and reliability, I-V models for circuit simulation, design for control of short channel effects, silicon-on-insulator, new device structures. Prerequisite: ECE 441 or equivalent

**586 Topics in Decision and Control** Credit: 4 hours.

Lectures and discussions related to advanced topics and new areas of interest in decision and control theory, including hybrid, sampled-data, and fault tolerant systems, control over networks, vision-based control, system estimation and identification, and dynamic games. May be repeated up to 12 hours within a semester, and up to 20 hours total for the course. Students may not receive additional credit towards a degree from multiple offerings of this course if those offerings have significant overlap, as determined by the ECE department. Prerequisite: As specified each semester or consent of instructor. It is expected that each offering will have a 500-level course as prerequisite or co-requisite.

**588 Electricity Resource Planning** Credit: 4 hours.

(ECE 488) Techniques in electricity resource planning including methodologies for reliability evaluation and assessment, production costing, marginal costing, supply-side and demand-side planning, integrated planning, and planning under competition. Prerequisite: MATH 415, ECE 413, and ECE 476; or consent of instructor

**589 Robot Control Theory** Credit: 4 hours.

(ECE 489) Same as GE 522. See GE 522.

**590 Grad Sem in Special Topics** Credit: 0 to 2 hours.

(ECE 490) Lectures and discussions on current research and literature on advanced topics in electrical engineering. May be repeated. Approved for S/U grading only. Prerequisite: Advanced standing; consent of instructor.

**594 Math Models of Language** Credit: 3 or 4 hours.

(ECE 494) Mathematical models of linguistic structure and their implementation in computational algorithms used in automatic speech understanding and speech synthesis. Statistical and automata theoretic techniques are studied allowing a quantitative description of acoustic-phonetics, phonology, phonotactics, lexicons, syntax and semantics. Students will use the methods to build components of a speech understanding system. Same as LING 594. For 4 hours credit, an extended project is required. Prerequisite: ECE 537 or consent of instructor.

**596 Master's Project** Credit: 1 to 8 hours.

(ECE 496) Graduate-level individual or team projects in electrical and computer engineering emphasizing advanced engineering analysis and design. May be repeated to a maximum of 16 hours. Only one unit of ECE 496 can be included in the 8 units required for the M. S. degree in Electrical Engineering. Credit in ECE 496 cannot be included in the 16 post-M. S. units required for the Ph.D. degree in Electrical Engineering. Prerequisite: Graduate standing in ECE. Students with deferred credit for ECE 599 may not register in ECE 596 without consent of the ECE department.

**597 Individual Study in ECE** Credit: 1 to 8 hours.

(ECE 498) Individual projects. Prerequisite: Consent of instructor.

**598 Special Topics in ECE** Credit: 0 to 4 hours.

(ECE 497) Lectures and discussions relating to new areas of interest. May be repeated. Prerequisite: As specified for each topic offering; see Schedule or departmental course information.

**599 Thesis Research** Credit: 0 to 16 hours.

(ECE 499) May be repeated. Approved for S/U grading only.