Course Catalog - Spring 2008

Electrical and Computer Engineering

101 ***Exploring Digital Info Technol*** 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 Computer or Electrical Engineering majors.
This course satisfies the General Education Criteria for a Physical Sciences course.

110 ***Intro Elec & Computer Engrg*** credit: 4 hours.
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 concurrent registration in MATH 220 or MATH 221.

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, and simple data structures. Credit is not given for both ECE 190 and CS 125.

199 ***Undergraduate Open Seminar*** credit: 1 to 5 hours.
Approved for both letter and S/U grading. May be repeated.

200 ***Seminar*** credit: 0 hours.
Discussions of educational programs, career opportunities, and other topics in electrical and computer engineering. Approved for S/U grading only. For Computer Engineering and Electrical Engineering majors only.

205 ***Elec & Electronic Circuits*** credit: 3 hours.
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. Credit is not given to Computer or Electrical Engineering majors. Prerequisite: PHYS 212.

206 ***Elec & Electronic Circuits Lab*** credit: 1 hours.
Laboratory instruments and basic measurement techniques, electric circuits, CMOS logic circuits, DTL and TTL circuits, and op-amps. Credit is not given to Computer or Electrical Engineering majors. Prerequisite: PHYS 212; concurrent registration in ECE 205.

210 ***Analog Signal Processing*** credit: 4 hours.
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. Credit is not given for both ECE 210 and ECE 211. Prerequisite: ECE 110 and PHYS 212; credit or concurrent registration in MATH 285 or MATH 286.

211 ***Analog Circuits & Systems*** credit: 2 hours.
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, and Laplace transform. Credit is not given for both ECE 211 and ECE 210. Prerequisite: ECE 110 and PHYS 212; credit or concurrent registration in MATH 285 or MATH 286.

280 ***Biomedical Imaging*** credit: 3 hours.
Introduction to the physics and engineering principles associated with magnetic resonance, ultrasound, computed

tomography, and nuclear imaging. Same as BIOE 280. Prerequisite: MATH 285 or MATH 286.

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 Engrg 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 313.

313 ***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. Prerequisite: ECE 210.

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, and legal obligations. Philosophical analysis of normative ethical theories. Case studies. Same as PHIL 316. Credit is not given for both ECE 316 and CS 210. Junior standing is required. Prerequisite: RHET 105.
This course satisfies the General Education Criteria for a Advanced Composition, and Hist&Philosoph Perspect course.

317 ***ECE Technology & 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 Computer or Electrical Engineering majors. Prerequisite: One of MATH 220, MATH 221, MATH 234.

328 ***Computer Solutions EM Probs I*** credit: 1 hours.
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.
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.
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.
Design and development of assembly language programs; input-output, interrupts, and 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.

391 ***Computer Systems Engineering*** credit: 3 hours.
Introduction to the concepts and abstractions central to the development of modern computing systems, with an emphasis on the systems software that controls interaction between devices and other hardware and application programs. Material includes input-output semantics, synchronization, interrupts, multitasking, virtualization of abstractions. Emphasis on learning to operate effectively in teams. Credit is not given for both ECE 391 and CS 241. Prerequisite: ECE 290 or CS 231. Recommended: ECE 190.

395 ***Advanced Digital Projects Lab*** credit: 2 or 3 hours.
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.

396 ***Honors Project*** credit: 1 to 4 hours.
Special project or reading course for James Scholars in engineering. May be repeated. Prerequisite: Consent of instructor.

397 ***Individual Study in ECE*** credit: 0 to 4 hours.
Individual Projects. Approved written application to department as specified by department or instructor is required. Approved for both letter and S/U grading. Prerequisite: Consent of instructor.

398 ***Special Topics in ECE*** credit: 0 to 4 hours.
Lectures and discussions relating to new areas of interest. May be repeated if topics vary. Prerequisite: As specified for each topic offering; see Schedule or departmental course information.

399 ***Honors Seminar*** credit: 1 to 4 hours.
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. For Computer Engineering and Electrical Engineering majors with senior standing. Prerequisite: 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, ECE 290, and 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.

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, and applications of digital signal processing. Prerequisite: ECE 210.

411 ***Computer Organization & Design*** credit: 4 hours.
Basic computer organization and design, computer arithmetic, control design and microprogramming, memory organization, I/D design, and reliability/performance evaluation; laboratory for computer design implementation, simulation, and layout. Credit is not given toward graduate degrees in Electrical and Computer 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.

414 ***Biomedical Instrumentation*** credit: 3 hours.
Same as BIOE 414. See BIOE 414.

415 ***Biomedical Instrumentation Lab*** credit: 2 hours.
Same as BIOE 415. See ECE 415.

417 ***Multimedia Signal Processing*** credit: 4 hours.
Basic characteristics of speech and image signals; important analysis and synthesis tools for multimedia signal processing including subspace methods, Bayesian networks, hidden Markov models, and factor graphs; applications to biometrics (person identification), human-computer interaction (face and gesture recognition and synthesis), and audio/visual databases (indexing and retrieval). Emphasis is on a set of MATLAB machine problems which provide hands-on experience. Prerequisite: ECE 313 and ECE 410.

418 ***Image & Video Processing*** credit: 4 hours.
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 313, STAT 400, IE 300, MATH 461; MATH 415; experience with C programming language.

420 ***Digital Signal Processing Lab*** credit: 2 hours.
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.
Same as NPRE 421 and PHYS 479. See NPRE 421.

422 ***Computer Security I*** credit: 3 or 4 hours.
Same as CS 461. See CS 461.

424 ***Computer Security II*** credit: 3 or 4 hours.
Same as CS 463. See CS 463.

425 ***Intro to VLSI System Design*** credit: 3 hours.
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.
Same as CS 425 and CSE 424. See CS 425.

430 ***Power Ckts & Electromechanics*** credit: 3 hours.
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, and laboratory demonstration. Credit is not given toward graduate degrees in Electrical and Computer Engineering. Prerequisite: ECE 210.

431 ***Electric Machinery*** credit: 4 hours.
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.
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, and digital simulation of inter-connected machines. Prerequisite: ECE 431.

435 ***Computer Networking Laboratory*** credit: 3 or 4 hours.
Design, apply, analyze, and evaluate communication network protocols under both Linux and Windows 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.
Gives 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.

439 ***Wireless Networks*** credit: 3 or 4 hours.
Overview of wireless network architectures including cellular networks, local area networks, multi-hop wireless networks such as ad hoc networks, mesh networks, and sensor networks; capacity of wireless networks; medium access control, routing protocols, and transport protocols for wireless networks; mechanisms to improve performance and security in wireless networks; energy-efficient protocols for sensor networks. Same as CS 439. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: 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 and Computer 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.
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 and Computer 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.
Laboratory to accompany ECE 442. Credit is not given toward graduate degrees in Electrical and Computer 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.
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, and 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.
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 and Computer Engineering. For Computer Engineering and Electrical Engineering majors with senior standing.

447 ***Active Microwave Ckt Design*** credit: 3 hours.
Laboratory and lecture course on microwave circuit design of amplifiers, oscillators, and mixers. Prerequisite: ECE 450 and ECE 453.

448 ***Artificial Intelligence*** credit: 3 or 4 hours.
Same as CS 440. See CS 440.

449 ***Computer Solutions EM Probs II*** credit: 1 hours.
Solution of selected electromagnetics problems at the ECE 450 level using personal computers. Credit is not given toward graduate degrees in Electrical and Computer Engineering. Prerequisite: ECE 328; credit or concurrent registration in ECE 450.

450 ***Lines, Fields, and Waves*** credit: 3 hours.
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 and Computer Engineering. Prerequisite: ECE 329.

451 ***Adv Microwave Measurements*** credit: 3 hours.
Manual- and computer-controlled laboratory analysis of circuits at microwave frequencies. Prerequisite: ECE 450.

452 ***Electromagnetic Fields*** credit: 3 hours.
Plane waves at oblique incidence, wave polarization, anisotropic media, radiation, space communications, and waveguides. Prerequisite: ECE 450.

453 ***Radio Communication Circuits*** credit: 4 hours.
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.
Antenna parameters; polarization of electromagnetic waves; basic antenna types; antenna arrays; broadband antenna design; and antenna measurements. Prerequisite: ECE 450.

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

457 ***Microwave Devices & Circuits*** credit: 3 hours.
Electromagnetic wave propagation, microwave transmission systems, passive components, microwave tubes, solid state microwave devices, microwave integrated circuits, S-parameter analysis, and microstrip transmission lines. Prerequisite: ECE 440 and ECE 450.

458 ***Applic of Radio Wave Propag*** credit: 3 hours.
Terrestrial atmosphere, radio wave propagation, and applications to radio sensing and radio communication.

Prerequisite: ECE 450.

459 ***Communications I*** credit: 3 hours.
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 313.

460 ***Optical Imaging*** credit: 3 hours.
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 313 or STAT 400.

461 ***Communications II*** credit: 3 hours.
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.
Design of combinational networks, hazards, finite state 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.
A laboratory course for digital communications systems. Gives hands-on experience in the configuration and performance evaluation of digital communication systems employing both radio and optical signals. Prerequisite: ECE 459. Recommended: credit or concurrent registration in ECE 461.

464 ***Power Electronics*** credit: 3 hours.
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 Communications 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 313 and ECE 450. Recommended: credit or concurrent registration in ECE 459 and ECE 466.

466 ***Optical Communications 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.

467 ***Biophotonics*** credit: 3 hours.
An overview of the field of biophotonics, divided into three segments: (1) fundamental principles of light, optics, lasers, biology, and medicine; (2) diagnostic biophotonics including imaging, spectroscopy, and optical biosensors; (3) therapeutic applications of biophotonics including laser ablation and photodynamic therapies. Includes student review and presentation of current scientific literature and tours of microscopy facilities. Same as BIOE 467. Prerequisite: One of ECE 455, ECE 460, PHYS 402.

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: ECE 210; ECE 329; PHYS 214; one of STAT 400, IE 300, ECE 313.

469 ***Power Electronics Laboratory*** credit: 2 hours.
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; credit or concurrent registration in ECE 464.

470 ***Introduction to Robotics*** credit: 4 hours.
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 MATH 418; ECE 210 or GE 320.

473 ***Fund of Engrg Acoustics*** credit: 3 or 4 hours.
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 285 or MATH 286.

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

475 ***Modeling of Bio-Systems*** credit: 3 or 4 hours.
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: ECE 210 or GE 320.

476 ***Power System Analysis*** credit: 3 hours.
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.
Studies economic operation of power systems, system protection, power system stability, dynamics and control of power systems, high voltage DC transmission, load flow interface, and digital simulation. Prerequisite: ECE 476.

478 ***Formal Software Devel Methods*** credit: 3 or 4 hours.
Same as CS 477. See CS 477.

480 ***Magnetic Resonance Imaging*** credit: 3 or 4 hours.
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. Prerequisite: Recommended: ECE 410.

482 ***Digital IC Design*** credit: 3 hours.
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.
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.
Principles of advanced methods of pattern delineation, pattern transfer, and modern material growth and how these are applied to produce novel and high performance devices and circuits in various electronic materials with special emphasis on semiconductors. Issues in computer simulation of processes and the manufacturing of devices and circuits. Prerequisite: ECE 444.

485 ***MEMS Devices & Systems*** credit: 3 hours.
Presents an introduction to the principles, fabrication techniques, and applications of microelectromechanical systems (MEMS). Gives 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. For engineering majors with senior standing.

486 ***Control Systems*** credit: 4 hours.
Analysis and design of control systems with emphasis on modeling, state variable representation, computer solutions, modern design principles, and laboratory techniques. Prerequisite: ECE 210.

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

488 ***Compound Semicond & Devices*** credit: 3 hours.
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 and ECE 450.

489 ***Robot Dynamics and Control*** credit: 4 hours.
Same as GE 422 and ME 446. See GE 422.

490 ***Introduction to Optimization*** credit: 3 or 4 hours.
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 241 or MATH 380.

491 ***Numerical Analysis*** credit: 3 or 4 hours.
Same as CS 450, CSE 401, and MATH 450. See CS 450.

492 ***Parallel Progrmg: Sci & Engrg*** credit: 3 or 4 hours.
Same as CS 420 and CSE 402. See CS 420.

493 ***Advanced Engineering Math*** credit: 3 or 4 hours.
Same as MATH 487. See MATH 487.

495 ***Proj & Lect in Quantum Electr*** credit: 3 hours.
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. Senior standing required. Prerequisite: ECE 487 recommended.

497 ***Senior Research Project*** credit: 2 hours.
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. ECE 497 and ECE 499 taken in sequence fulfill the Advanced Composition Requirement. No graduate credit. Prerequisite: 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.
Lectures and discussions relating to new areas of interest. May be repeated if topics vary. Prerequisite: As specified for each topic offering; see Schedule or departmental course information.

499 ***Senior Thesis*** credit: 2 hours.
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. To fulfill the Advanced Composition Requirement, credit must be earned for both ECE 497 and ECE 499. 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.
Required of all graduate students. Approved for S/U grading only.

511 ***Computer Architecture*** credit: 4 hours.
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.

512 ***Computer Microarchitecture*** credit: 4 hours.
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 and CS 426.

513 ***Vector Space Signal Processing*** credit: 4 hours.
Rigorous presentation of key mathematical tools in a vector space framework, including: finite and infinite dimensional vector spaces, Hilbert spaces, orthogonal projections, subspace techniques, least-squares methods, matrix decomposition, conditioning and regularizations, bases and frames, the Hilbert space of random variables, random processes, iterative methods; and their applications in signal processing, including: inverse problems, filter design, sampling, interpolation, sensor array processing, and signal and spectral estimation. Prerequisite: ECE 313, ECE 410, and MATH 415.

515 ***Control System Theory & Design*** credit: 4 hours.
Fundamental course on feedback control systems, which emphasizes state space techniques. Basic principles, modeling, analysis, stability, structural properties, optimization and design to meet specifications. Prerequisite: ECE 486.

517 ***Nonlinear & Adaptive Control*** credit: 4 hours.
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.
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.
Same as NPRE 522. See NPRE 522.

523 ***Gaseous Electronics & Plasmas*** credit: 4 hours.
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: ECE 452 or PHYS 485.

525 ***Nucl-Electr Energy Conversion*** credit: 4 hours.
Same as NPRE 525. See NPRE 525.

528 ***Analysis of Nonlinear Systems*** credit: 4 hours.
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 and MATH 285.

530 ***Large-Scale System Analysis*** credit: 4 hours.
Fundamental techniques for the analysis of large-scale electrical systems, including methods for nonlinear and switched systems. The importance of the structural characteristics of such systems is stressed. Key aspects of static and dynamic analysis methods are presented. Prerequisite: ECE 464 and ECE 476.

531 ***Theory of Guided Waves*** credit: 4 hours.
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. Recommended: MATH 556.

532 ***Compnd Semicond & Diode Lasers*** credit: 4 hours.
Compound semiconductor materials and their optical properties. Diode lasers are discussed in detail including quantum well heterostructure lasers, strained layer lasers, and quantum wire and quantum dot lasers. Current topics in diode laser development are included. Prerequisite: ECE 440 and PHYS 486. Recommended: ECE 455; credit or concurrent registration in ECE 536.

533 ***Parallel Computer Architecture*** credit: 4 hours.
Same as CS 533 and CSE 522. See CS 533.

534 ***Random Processes*** credit: 4 hours.
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 313, MATH 461, STAT 400.

535 ***Theory of Semicond & Devices*** credit: 4 hours.
Introductory quantum mechanics of semiconductors; energy bands; dynamics of Block 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.
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. Recommended: ECE 488.

537 ***Speech Processing Fundamentals*** credit: 4 hours.
Provides an intuitive understanding of speech processing by the auditory system, in three parts. I: The theory of acoustics of speech production, introductory acoustic phonetics, inhomogeneous transmission line theory (and reflectance), room acoustics, the short-time Fourier Transform (and its inverse), and signal processing of speech (LPC/CELP/VQ). II: Psychoacoustics of speech perception, critical bands, masking (JNDs), and the physiology of the auditory pathway (cochlear modeling). III: Information theory entropy, channel capacity, the confusion matrix, state models, EM algorithms, and Bayesian networks. Classic papers on speech processing and speech perception assigned and presented by student groups. Matlab (or equivalent) programming is required for many of the homeworks. Prerequisite: ECE 410.

539 ***Adv Theory Semicond & Devices*** credit: 4 hours.
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.
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: CS 257; credit or concurrent registration in ECE 520.

541 ***Computer Systems Analysis*** credit: 4 hours.
Development of analytical models of computer systems and application of such models to performance evaluation; topics include scheduling policies, paging algorithms, multiprogrammed resource management, and queuing theory. Same as CS 541 and CSE 524. Prerequisite: One of ECE 313, MATH 461, MATH 463.

542 ***Fault-Tolerant Dig Syst Design*** credit: 4 hours.
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, and 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.

543 ***Dig Testing & Design for Test*** credit: 4 hours.
Fundamental techniques of detecting failures in complex digital systems, algorithms for automatic test generation, and 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.

544 ***Topics in Signal Processing*** credit: 4 hours.
Lectures and discussions related to advanced topics and new areas of interest in signal processing; including speech, image and multidimensional processing. May be repeated 8 hours in a term to a total of 20 hours. Credit towards a degree from multiple offerings of this course is not given if those offerings have significant overlap, as determined by the ECE department. Prerequisite: As specified each term. It is expected that each offering will have a 500-level course as prerequisite or co-requisite.

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

547 ***Topics in Image Processing*** credit: 4 hours.
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 313 and ECE 410.

548 ***Models of Cognitive Processes*** credit: 4 hours.
Same as CS 548. See CS 548.

549 ***Computer Vision*** credit: 4 hours.
Examines information processing approaches to computer vision, 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.

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

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. Prerequisite: ECE 470.

551 ***Digital Signal Processing II*** credit: 4 hours.
Reviews basic concepts of digital signals and systems; examines computer-aided digital filter design, quantization effects, decimation and interpolation, and fast algorithms for convolution and the DFT; and introduces adaptive signal processing. Same as CSE 542. Prerequisite: ECE 313 and ECE 410.

552 ***Numerical Circuit Analysis*** credit: 4 hours.
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.
Theoretical and algorithmic foundations of deterministic optimal control theory, including calculus of variations, maximum principle, and principle of optimality; the Linear-Quadratic-Gaussian design; differential games and H-infinity optimal control design. Prerequisite: ECE 313 and ECE 515.

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

558 ***Digital Imaging*** credit: 4 hours.
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 313 and ECE 410.

559 ***Topics in Communications*** credit: 4 hours.
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, if topics vary, to a maximum of 12 graduate hours; may be repeated in separate terms, if 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 will receive credit separately for each section. Credit toward a degree from multiple offerings of this course is not given if those offerings have significant overlap, as determined by the Electrical and Computer Engineering department. Prerequisite: As specified each term. (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.
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 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.
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.

563 ***Information Theory*** credit: 4 hours.
Mathematical models for channels and sources; entropy, information, data compression, channel capacity, Shannon's theorems, and rate-distortion theory. Same as CS 578 and STAT 563. Prerequisite: One of ECE 534, MATH 464, MATH 564.

567 ***Communication Network Analysis*** credit: 4 hours.
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; one of ECE 534, MATH 464, MATH 564.

568 ***Model & Cntrl Electromech Syst*** credit: 4 hours.
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.

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

570 ***Nonlinear Optics*** credit: 4 hours.
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.
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; and inverse problems. Prerequisite: MATH 446; ECE 520 or PHYS 505.

572 ***Quantum Electronics*** credit: 4 hours.
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.
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; credit or concurrent registration in ECE 530.

576 ***Power System Dynm & Stability*** credit: 4 hours.
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; credit or concurrent registration in ECE 530.

577 ***Advanced Antenna Theory*** credit: 4 hours.
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.
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. Recommended: ECE

577.

579 ***Computational Complexity*** credit: 4 hours.
Same as CS 579 and MATH 578. See CS 579.

580 ***Optimiz by Vector Space Methds*** credit: 4 hours.
Introduction to normed, Banach, and Hilbert spaces; applications of the projection theorem and the Hahn-Banach Theorem to problems of minimum norm, least squares estimation, mathematical programming, and optimal control; the Kuhn-Tucker Theorem and Pontryagin's maximum principle; introduction to iterative methods. Same as MATH 587. Prerequisite: MATH 415 or MATH 482; MATH 447.

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

583 ***Semiconductor Nanotech Lab*** credit: 4 hours.
A lab course treating the practical aspects of design and testing of nanometer-scale, MOS circuit technology. Emphasis on process integration and the interrelationship between the process flow and device/circuit performance. Experience with state-of-the-art, process and device simulation tools; nanostructure characterization using atomic force and transmission electron microscopies; and capacitance, conductance and scattering parameter measurements used to extract parameters for circuit models. Prerequisite: ECE 444; PHYS 485 or PHYS 486.

584 ***IC Reliability Engineering*** credit: 4 hours.
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 313 and ECE 440.

585 ***MOS Device Modeling & Design*** credit: 4 hours.
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, and new device structures. Prerequisite: ECE 441.

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 term, and up to 20 hours total for the course. Credit towards a degree from multiple offerings of this course is not given if those offerings have significant overlap, as determined by the ECE department. Prerequisite: As specified each term. It is expected that each offering will have a 500-level course as prerequisite or co-requisite.

588 ***Electricity Resource Planning*** credit: 4 hours.
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 313, and ECE 476.

589 ***Robot Control Theory*** credit: 4 hours.
Same as GE 522. See GE 522.

590 ***Grad Sem in Special Topics*** credit: 0 to 2 hours.
Lectures and discussions on current research and literature on advanced topics in electrical engineering. Approved for S/U grading only. May be repeated. Prerequisite: Consent of instructor.

594 ***Math Models of Language*** credit: 3 or 4 hours.
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. The methods are used to build components of a speech understanding system. Same as LING 594. For 4 hours credit, an extended project is required. Prerequisite: ECE 537.

596 ***Master's Project*** credit: 1 to 8 hours.
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 4 hours of ECE 496 can be included in the 32 hours required for the M. S. degree in Electrical Engineering. Credit in ECE 496 cannot be included in the 64 post-M. S. hours required for the Ph.D. degree in Electrical Engineering. 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.
Individual projects. Approved written application to department as specified by department or instructor is required. Prerequisite: Consent of instructor.

598 ***Special Topics in ECE*** credit: 0 to 4 hours.
Lectures and discussions relating to new areas of interest. May be repeated if topics vary. Prerequisite: As specified for each topic offering; see Schedule or departmental course information.

599 ***Thesis Research*** credit: 0 to 16 hours.
Approved for S/U grading only. May be repeated.