ELECTRICAL AND
COMPUTER ENGINEERING

COLLEGE OF ENGINEERING

Graduate Faculty:


Brown, David P., Professor, Emeritus, Ph.D., Michigan State University, 1961; 1983.

Chen, Ying (Ada), Assistant Professor, Ph.D., Duke, 2007; 2007. Biomedical imaging, image reconstruction, digital tomosynthesis, image quality analysis, signal and image processing, simulation and computing.

Daneshdoost, Morteza, Professor, Ph.D., Drexel University, 1984; 1984. Electric power systems, linear systems and circuits, control systems optimization techniques, expert systems, computer graphics, MMI.

Feiste, Vernold, K., Associate Professor, Emeritus, Ph.D., University of Missouri-Columbia, 1966; 1966.

Galanos, Giafkos D., Professor and Chair, Ph.D., University of Manchester, England, 1970; 1987. Power systems, HVDC transmission, power electronics systems.


Harackiewicz, Frances J., Professor, Ph.D., University of Massachusetts-Amherst, 1990; 1989. Electromagnetics, antenna theory and design, microwaves, microstrip phased arrays and anisotropic materials.

Hatziadoniu, Constantine, Professor, Ph.D., West Virginia University, 1987; 1987. Power systems modeling, simulation and control, high voltage DC transmission, power electronics, power systems transient.

Hu, Chia-Lun John, Professor, Emeritus, Ph.D., University of Colorado, 1966; 1981.

Kagaris, Dimitrios, Professor, Ph.D., Dartmouth College, 1994; 1995. VLSI design automation, digital circuit testing, communication networks.

Osborne, William, Professor, Emeritus, Ph. D., New Mexico State University, 1970; 2005.

Pourboghrat, Farzad, Professor, Ph.D., University of Iowa, 1984; 1984. Optimal control, robust and adaptive control, dynamic neural networks, robotics, embedded control systems, sensor networks.

Qin, Xianping, Assistant Professor, Ph.D. Northwestern University, 2005; 2008.

Ramaprasad, Harini, Assistant Professor, Ph.D., North Carolina State University, 2008; 2008.

Rawlings, Charles A., Professor, Emeritus, Ph.D., Southern Illinois University Carbondale, 1974; 1964.

Sayeh, Mohammad R., Professor, Ph.D., Oklahoma State University, 1985; 1986. Neural networks, optical computing, image processing, stochastic modeling, quantum electronics.

Schoen, Alan, Professor, Emeritus, Ph.D., University of Illinois, 1958; 1973.

Smith, James G., Professor, Ph.D., Emeritus, University of Missouri-Rolla, 1967; 1966.

Tragoudas, Spyros, Professor, Ph.D., University of Texas at Dallas, 1991; 1999. Design automation for VLSI, testing and verification of digital circuiting, computer networks.

Viswanathan, Ramarayanan, Professor and Interim Dean, Ph.D., Southern Methodist University, 1983; 1983. Detection and estimation theory, spread spectrum communication, communication theory, signal processing.

Wang, Haibo, Associate Professor, Ph.D., University of Arizona, 2002; 2002. Mixed-signal VLSI design and testing, digital VLSI, VLSI design automation.

Weng, Ning, Assistant Professor, Ph.D., University of Massachusetts at Amherst, 2005; 2005. High performance routers, network processors, system-on-a-Chip, computer architectures.

Zhang, Wei, Associate Professor, Ph.D., Pennsylvania State University, 2003; 2003. Computer architecture, compilers, hardware/software co-design.

Master of Science Degree in Electrical and Computer Engineering

The College of Engineering offers graduate programs leading to the Master of Science and Doctor of Philosophy degrees. The Department of Electrical and Computer Engineering offers programs of study and research leading to the Master of Science degree in Electrical and Computer Engineering and the Doctor of Philosophy in Electrical and Computer Engineering. The Department provides a rich environment for educational and professional advancement in the following areas:

- Antennas, circuits and systems theory, electromagnetics, robust and adaptive control, robotics, embedded control, MEMS, plasma processing, energy conversion, power systems, power electronics, pattern recognition, image processing, biomedical engineering, neural networks, opti-
cal computing, stochastic modeling, wireless communications, detection and estimation theory, communication networks, mobile ad hoc networks, sensor networks, digital systems, programmable ASICs design, bioengineering, computer architecture, CMOS VLSI, fault tolerance, mixed signal testing and design, low power system design, hardware/software co-design, synthesis and verification of digital systems, physical design automation, and VLSI testing.

The ECE programs of study provide a balance between formal classroom instruction and research, and are tailored to the individual student's academic and professional goals. Graduates of the program enjoy excellent employment opportunities and are highly recruited worldwide in industry, government, and academia.

Admission. The program is designed for individuals holding a Bachelor of Science degree in electrical or computer engineering or related field. Qualified applicants with Bachelor of Science in other areas of engineering and science may be able to enroll in the program with additional preparation. (Approved by the Department on a case-by-case basis).

Admission to the program is based on the following factors: grade point average, class ranking, GRE scores (especially quantitative) and faculty recommendation letters. The admission requirements of the Department are higher than the minimum requirements of the Graduate School. The TOEFL score requirement for international applicants is 550 (the same as required by the Graduate School). Admission to the program is granted by the Chair of the Department, upon recommendation by the faculty.

This program requires a nonrefundable $50.00 application fee that must be submitted with the application for Admissions to Graduate Study in Electrical and Computer Engineering. Applicants may pay this fee by credit card if applying electronically. Applicants submitting a paper application must pay by personal check, cashier's check, or money order made out to SIU, and payable to a U.S. Bank.

Requirements. The Department offers two different programs leading to the Master of Science degree, the Thesis and the Non-thesis program. The requirements for each of the programs are as follows:

The thesis program leading to the Master of Science degree in Electrical and Computer Engineering requires 30 semester hours of credit. Six hours of thesis (ECE 599), one hour of ECE seminar (ECE 580) and at least fifteen hours of 500-level courses are required. Thus, a maximum of eight hours of 400-level courses could be counted toward the degree requirements. With the approval of the Department, a maximum of six hours from academic units outside the ECE Department could be applied toward the degree. The degree is awarded following a comprehensive examination covering the candidate's entire program of study, including the thesis.

The non-thesis program leading to the Master of Science degree in Electrical and Computer Engineering requires 30 semester hours of credit. At least 22 hours should be in 500-level courses, thus, a maximum of eight hours of 400-level courses could be counted toward the degree requirements. With the approval of the Department, a maximum of six hours from academic units outside the ECE Department could be applied toward the degree.

Qualified individuals with exceptional credentials may apply for assistantships, fellowships, and scholarships, either at the same time they apply for admission, or at any time during the course of their studies.

Please address any correspondence to "Master of Science Program," Department of Electrical and Computer Engineering, Southern Illinois University Carbondale, Carbondale, Illinois 62901-6603. For telephone inquiries please call 618-536-2364, and refer to the Master of Science Program. The Electrical and Computer Engineering facsimile number is 618-453-7972, and the email address is ecdept@siu.edu. The Electrical and Computer Engineering home page address is http://heera. engr.siu.edu /elec/index.htm.

ECE/LAW in Electrical and Computer Engineering/Juris Doctor

Southern Illinois University Carbondale is one of the few institutions in the country to offer a concurrent degree in Electrical and Computer Engineering and Law. Students prepared for this program are expected to possess an undergraduate degree in electrical engineering, computer engineering or a related field. Students are able to tailor their program of study to focus on legal principles and policies involving the engineering profession including patent, copyright, trademark, environmental and electronic commerce laws, federal regulation of electronic media and other engineering-related areas of law.

Students must meet the requirements of admission and be admitted separately to the Master of Science program in Electrical and Computer Engineering and the School of Law. Accepted students could complete the concurrent program in as few as three years, including summers. Law students interested in this program should consult with the School of Law Associate Dean for Academic Affairs and with the Chair of the Department of Electrical and Computer Engineering.

Thesis Option

The course of study consists of the following:

- Twenty-one hours of ECE courses, including ECE 599, Master's Thesis (six hours) and ECE 592, Special Investigations (three hours).
- Eighty-one hours of LAW courses, including nine hours from an approved list of LAW courses.

The nine hours of ECE 599 and ECE 592 are applied toward the J.D. degree, for a total of 90 hours. The nine hours of LAW courses (from the approved list of LAW courses) are applied toward the M.S. degree in ECE, for a total of 30 hours.
Non-Thesis Option

The course of study consists of the following:

- Twenty-one hours of ECE courses, including ECE 593, Advanced Topics (three hours) and ECE 592, Special Investigations (three hours).
- Eighty-one hours of LAW courses, including nine hours from an approved list of LAW courses.

Nine hours of ECE courses, including ECE 592 and ECE 593 are applied toward the J.D. degree, for a total of 90 hours. The nine hours of LAW courses (from the approved list of LAW courses) are applied toward the M.S. in ECE, for a total of 30 hours.

List of Approved LAW Courses

- LAW 525 Federal Income Tax
- LAW 528 Corporations
- LAW 545 International Trade Law
- LAW 546 Federal Business Taxation
- LAW 548 Environmental Law I: Laws and Policies
- LAW 559 International Business Transactions
- LAW 562 Copyright Law
- LAW 564 Law and Economics
- LAW 565 Antitrust
- LAW 567 Electronic Commerce
- LAW 568 Water Law
- LAW 586 Business Planning
- LAW 610 Federal Regulation of Electronic Media
- LAW 630 Intellectual Property
- LAW 634 Trademarks and Unfair Competition
- LAW 660 Food, Drug and Medical Device Law

Doctor of Philosophy in Electrical and Computer Engineering

Educational Objectives. The program is designed to achieve the following academic objectives: (a) to fulfill the obligation of the ECE Department to provide high quality education through the doctoral level as is mandated by the mission statement of the University; (b) to provide the students with the training necessary to successfully apply the fundamental concepts and methods of electrical and computer engineering to specific areas of research and development; (c) to provide the graduates with the ability to independently organize and conduct research in electrical and computer engineering; (d) to provide the graduates with the ability to concisely disseminate existing and new knowledge and to accurately present their research plans in writing.

Program Structure. The program offers two areas of concentration: (a) Electrical Engineering and (b) Computer Engineering. The concentration in Electrical Engineering offers three tracks: (1) Communications, (2) Electronics & Optics, (3) Systems. The core for each of the areas above includes six courses as follows:

Admission. Admission to the program requires a Master of Science degree in Electrical or Computer Engineering or a related field with a GPA of 3.25/4.0 or higher. Applications for admission must include the following: a statement of interest, transcripts, GRE scores, three reference letters and TOEFL score (where appropriate), as required by the Graduate School. Admission to the program is made by the Department Chair upon recommendation by the ECE Graduate Committee.

Advisement. Upon admission the Chair assigns the advisor (and chair of the student’s committee) and two committee members, to assist the student in selecting the appropriate core courses and in developing a plan of study.

Curriculum. The curriculum consists of fifty hours of credit beyond the M.S. degree. Eighteen hours of 500-level ECE courses, of which nine hours must be taken from the selected core, three hours of mathematics, three additional hours of mathematics or science, two hours of seminar and twenty-four hours of dissertation. The mathematics and science courses must be approved by the student’s Committee. Core courses successfully completed for the M.S. degree can be used to fulfill the core requirements, but additional courses must be taken to satisfy the requirement of eighteen hours of 500-level ECE courses beyond the M.S. degree. The objective of the core is to provide the candidate with the foundation necessary to engage successfully in the selected research area. Thus, the core design fulfills the research tool requirement specified in the Graduate School guidelines.

Qualifying Examinations. Upon completion of the core courses the student may take the qualifying examination. This examination covers the material of the core courses selected and is administered by the student’s committee. If not successful, the committee may allow the student to repeat the whole or part of the examination one more time. The qualifying examination, in whole or in part, cannot be taken more than two times.
**Candidacy.** Admission to candidacy requires: (a) successful completion of the qualifying examination (which satisfies the research tool requirement of the Graduate School) and (b) successful completion of twenty-four hours of credit (which satisfies the residency requirement of the Graduate School).

**Dissertation Committee.** Following the admission to candidacy the Department Chair in consultation with the student’s advisor (dissertation supervisor) appoints the dissertation committee, which shall consist of five faculty members with at least one (but not more than two) outside the ECE Department. The student’s dissertation supervisor shall be one of the five members and shall chair this committee.

**Dissertation Proposal.** Following the admission to candidacy and upon completion of all the coursework, the candidate will prepare and submit a formal written dissertation proposal, defining the proposed research and the proposed line of inquiry. The candidate subsequently must make an oral presentation of the dissertation proposal to the members of the dissertation committee in an open forum. A public announcement of this event must be made at least five days in advance.

**Oral Examination.** In the framework of the oral presentation of the dissertation proposal, the candidate is expected to address and respond to any question (by the members of the committee) related to material covered by all the courses taken during his doctoral studies or to the background necessary for the specific area of the proposed research. In addition, the candidate is expected to defend the research methodology and the proposed line of inquiry.

**Dissertation Defense.** Upon completion of the dissertation, which must demonstrate the ability of the candidate to conduct independent research, the committee will administer the final oral examination. The objective of the final oral examination, conducted in an open forum, will be the defense of the dissertation. Upon satisfactory completion of the dissertation and the final oral examination the committee will recommend the candidate for the doctoral degree.

**Time Limits.** The upper or lower time limits for completion of each of the steps in the process are the same as those specified by the Graduate School for doctoral programs.

**Presentation Skills.** Technical writing and oral presentation skills are important particularly for a possible academic career. During the course of study the student will be provided with opportunities to develop these skills (by attending technical writing classes and seminars). It is desirable to assign some teaching assistant duties to the candidate to gain some teaching experiences. The dissertation committee shall evaluate the candidate’s skills both in technical writing and oral presentation.

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**Courses (ECE)**

Graduate work in the Department of Electrical and Computer Engineering is offered toward a concentration for the Master of Science degree in Engineering. Safety glasses are required for some of the courses in this department. Four-hundred-level courses in this department may be taken for graduate credit unless otherwise indicated in the course description.

**421-4 Synthesis with Hardware Descriptive Languages.** Fundamental concepts, techniques and tools for computer-aided design of simple digital systems. Modeling and simulation of digital systems using hardware descriptive languages. Behavioral, data flow and structural modeling. Synthesis, optimization and verification. Lecture and laboratory. Prerequisite: 327.


**423-4 Digital VLSI Design.** Principles of the design and layout of Very Large Scale Integrated (VLSI) circuits concentrating on the CMOS technology. MOS transistor theory and the CMOS technology. Characterization and performance estimation of CMOS gates, CMOS gate and circuit design. Layout and simulation using CAD tools. CMOS design of datapath subsystems. Design of finite state machines. Examples of CMOS system designs. Laboratory experience in CMOS VLSI design. Lecture and Laboratory (VLSI design). Prerequisite: 327 and 345.

**424-4 Microprocessor-Based System.** Microprocessor technology. Design, construction and programming of microprocessor-based systems. Lecture and laboratory. Cost of parts for microprocessor-based system, approximately $80. Prerequisite: 329 or concurrent enrollment or consent of instructor.

**425-4 VLSI Design and Test Automation.** Principles of the automated synthesis, verification, testing and layout of Very Large Scale Integrated (VLSI) circuits concentrating on the CMOS technology. Resource allocation and scheduling in high-level synthesis. Automation of the logic synthesis for combinational and sequential logic. The physical design automation cycle and CMOS technology considerations. Fault modeling and testing. Timing analysis. Laboratory experience using commercial tools for synthesis and layout. Prerequisite: 329, 345.

**428-4 Programmable ASICs Design.** Introduction to theoretical concepts and experimental design and construction of Application-Specific Integrated Circuits (ASICs). Rapid
432-4 Programming for Multi-Core Processors. Multi-core architecture, threads, thread execution models, thread priority and scheduling, concurrency, multi-threaded programming models, synchronization, performance measurement and local balance, software tools for multi-threaded programming. Prerequisite: 329.

440-4 CMOS Radio-Frequency Integrated Circuit Design I. The basics of CMOS RFIC design, including basic concepts in RFIC design, CMOS (active and passive) microwave devices, matching networks and signal flow graph, scattering parameter microwave circuit design and analysis methods. Lecture and laboratory. Prerequisite: ECE 329, CS 306 or consent of instructor.

441-4 Photonics I. Ray optics, wave optics, beam optics, polarization of light, statistical optics, photons and atoms. Prerequisite: 375 with a grade of C or better.

446-4 Electronic Circuit Design. Analysis and design of electronic circuits, both discrete and integrated. Computer-aided circuit design and analysis. Consideration of wideband, power and tuned amplifiers; switching circuits; feedback; and oscillators. Design projects. Lecture and laboratory. Laboratory fee of $10 to defray cost of consumable items. Prerequisite: 345, 375 or equivalent.

447-4 Electronic Devices. Fundamental principles of semiconductor carrier statistics, band diagrams, pn-junction diodes, Schottky diodes, BJTs, MOS capacitors and MOSFETs for advanced VLSI technology. Lecture and laboratory. Prerequisite: 345, 355 or equivalent.

448-4 Photonics II. Fourier optics, fiber optics, electro-optics, nonlinear optical media, acousto-optics, photonic switching, optical interconnections and optical storage. Prerequisite: 441 or consent of instructor.

456-3 Embedded Control and Mechatronics. Introduction to mechatronic systems, systems modeling and simulation, sensors and actuators, real-time interfacing, DSPs and microcontrollers, analysis or sampled-data systems, z-transform, digital control design techniques, emulation methods, direct method, industrial applications. Lecture and laboratory. Prerequisite: 315 and 356.

459-4 MEMS and Micro-Engineering. Introduction to micro electro-mechanical systems (MEMS), manufacturing techniques, microsensors, microactuators, microelectronics and micro-controllers. Lecture and laboratory. Prerequisite: 315 and 356.


468-4 Digital Signal Processing. Discrete time signals and systems; z-transform; discrete Fourier transform, fast Fourier transform algorithms; digital filter design; digital filter realizations. Lecture and laboratory. Prerequisite: 355.


472-4 Antennas I. Analysis, design, fabrication, measurement and CAD applied to basic antenna types. Fundamental parameters. Friis transmission equation. Impedance and pattern measurements. Resonant microstrip and wire antennas. Arrays and line sources. Lecture and Laboratory. Prerequisite: 375.


479-4 Microwave Engineering I. Electromagnetic theory, analysis, design, fabrication, measurement and CAD applied to passive networks at microwave frequencies. Topics include: Transmission lines, Waveguides, Impedance matching, Tuning, Resonators, Scattering parameters, the Smith Chart. Lecture and Laboratory. Prerequisite: 375.


Plants. Renewable Energy. Prerequisites: Consent of Instructor.


493-1 to 4 Special Topics in Electrical Engineering. Lectures on topics of special interest to students in various areas of electrical engineering. Designed to test new and experimental courses in electrical engineering. Prerequisite: consent of instructor.


523-3 Low Power VLSI Design. Source of power dissipation, technology impact on power dissipation, low power circuit techniques, energy recovery, synthesis of low power circuits, low power components. Prerequisite: 423.

524-3 Synthesis and Verification of Digital Circuits. Binary decision diagrams, finite state machines and finite automata. Design automation concepts in logic level synthesis, optimization and verification for combinational as well as sequential logic. Technology mapping. Prerequisite: 423, 425.

525-3 Advances in Physical Design Automation. Advances in the automation of VLSI layouts with emphasis on recent developments in deep submicron, FPGA and MCM technologies. Floorplanning, placement, routing objectives in high performance designs using deep submicron technology. Timing analysis in the presence of crosstalk. FPGA architectures and design with dynamically reconfigurable FPGAs. Physical design automation for MCMs. Prerequisite: 423, 425.

526-3 Network Processing Systems Design. Protocol processing, packet processing algorithms, classification and forwarding, queueing theory, switching fabrics, network processors, network systems design tradeoffs. Prerequisite: 422 and 429 or consent of the instructor.


529-3 Analog-to-Digital Conversion and Related Devices. Principles, analysis and design of analog-to-digital converters, video converters, voltage-to-frequency (V/F) and frequency-to-voltage (F/V) converters; universal synchronous/asynchronous receiver/transmitter circuits; hardware implementation of: Fourier analysis, infinite/finite impulse response (IIR/FIR) filters; microcoded systems, fixed and floating point accumulators. Two projects. Prerequisite: 428 and 465 or consent of instructor.

531-3 Mixed Signal VLSI Design. Fundamentals and practical circuit techniques of mixed-signal VLSI design, substrate coupling noise in mixed-signal ICs, D/A and A/D converters, filter circuits, techniques to partition mixed-signal circuits, prototyping and mixed-signal circuits by using FPGAs and FPAAs. Prerequisite: 423 or consent of the instructor.

532-3 Advanced Microprocessor Design. Superscalar pipeline, instruction level parallelism, out-of-order execution, register renaming, instruction/data prefetching, control speculation, data speculation, load forwarding, load by-passing, VLIW. Prerequisite: 429 or consent of instructor.

537-3 Integrated Photonics. Fundamentals of electromagnetic theory, waveguides, photonic structures including photonic crystals and integrated micro-ring resonator, numerical simulations of photonic integrated circuits using the beam propagation method, finite-difference time-domain method, rate equations, and fabrication processes. Prerequisite: ECE 441 or consent of instructor.

540-3 CMOS Radio-Frequency Integrated Circuit Design II. An overview of wireless transceiver architectures, high frequency amplifier design techniques, CMOS low noise amplifiers (LNA), mixers, oscillators, frequency synthesizers, power amplifiers, and CMOS RFIC testing. Prerequisite: 440 or equivalent.

541-3 Nanofabrication. Fundamentals of nanofabrication for integrated circuits, micro-electromechanical systems (MEMS), biosensors, and chemical sensors. Topics include: materials, hot processing and ion implantation, pattern transfer, thin films, and process integration. Prerequisite: Physics 320, 328; Chemistry 210; or equivalent.


546-3 Gaseous Electronics. Basic science of gas discharges and plasmas. Electrode phenomenon and plasma oscillations. Application of gas discharges to dry etching, plasma-assisted chemical vapor deposition, and sputtering. Prerequisite: consent of instructor.


548-3 Advanced Electronic Devices. A study of techniques in fabricating microelectronic and discrete electronic devices and influences on device design. Thick-film hybrid, thin-film hybrid, monolithic bipolar, and monolithic MOS technologies will be examined. Prerequisite: 345 and 447.

549-3 Fiber Optics Communication. Fundamentals of step index and graded index fiber waveguides using geometrical optics and Maxwell’s equations. Other topics include design criteria, practical coupling techniques, discussion of optical sources and detectors used in light-wave communications, system examples, characterization and measurement techniques. Prerequisite: 447 or 448 or consent of instructor.


551-3 Probability and Stochastic Processes for Engineers. (Same as Electrical Computer Engineering 521) Axioms of probability, random variables and vectors, joint distributions, correlation, conditional statistics, sequences of random variables, stochastic convergence, central limit theorem, stochastic processes, stationarity, ergodicity, spectral analysis, and Markov processes. Prerequisite: graduate student status.

552-3 Detection Theory. Signal detection in white and colored noise. Random waveforms. Matched filtering. Mary signal detection, nonparametric detection, sequential hypothesis testing, decision theoretic schemes. Applications in communication and radar signal processing. Prerequisite: 551 or consent of instructor.


554-3 Spread Spectrum Communication. Concepts of spread spectrum systems, frequency hopping, and direct sequence systems. Anti-jamming performance analysis, synchronization schemes, and systems with forward error correction. Prerequisite: 552 or consent of instructor.

555-3 Information Theory. Introduce the foundations of information theory as related to data compression and transmission of information. Contents: Entropy, block encoding, Huffman code, universal code, capacity, channel coding, Ergodic Theorem, Shannon-McMillan Theorem, rate-distortion theory, quantization, predictive coding, multi-terminal information networks. Prerequisite: 551 or Mathematics 480 or consent of instructor.

556-3 Digital Communications. Bandpass signals and systems characterization. Optimum receivers for detecting modulation signals in additive white Gaussian noise, block and convolutional code, communication through bandlimited channels. Prerequisite: 551 and Engineering 521 or consent of the instructor.

558-3 Digital Image Processing I. Basic concepts, scope and examples of digital image processing, digital image fundamentals, image sampling and quantization, an image model, relationship between pixels, enhancement in the spatial domain, enhancement in the frequency domain, image segmentation, basics of color image processing. Prerequisite: consent of instructor.


calculus. Combined estimation and control. Computational methods in optimal control. Prerequisite: 456 or consent of instructor.


566-3 **Adaptive Control.** Adaptive systems and adaptation mechanisms. Error system models, direct and indirect adaptive control methods, self-tuning control, model reference adaptive control, variable structure adaptive control, robust control, learning control. Design techniques and applications. Prerequisite: 456 or consent of instructor.

567-3 **Modern Biomedical Imaging.** Modern biomedical imaging. Diagnostic x-ray projection imaging. Tomographic imaging. Ultrasound imaging and therapy. Magnetic resonance imaging (MRI). Signal and noise characteristics. Image quality evaluation. Three-dimensional image reconstruction algorithms. Prerequisite: ECE355 or consent of instructor.

568-3 **Pattern Classification.** Classification models, discriminant functions, decision surfaces, generalized linear discriminant functions, parameter estimation, problems of dimensionality, component analysis. Fisher discriminant analysis, hidden Markov models, nearest neighbor rules, classification trees, string matching, resampling for classifier design and evaluation, clustering algorithms, projects. Prerequisite: consent of instructor.


572-3 **Neural Networks.** Anatomy and physiology of the cerebral cortex. Feed-forward Networks, Linear Associator, Multilayer Perceptrons. Feedback Networks, Hopfield Networks, ART. Applications to pattern recognition, robotics and speech processing. Optical and electronic implementations. Prerequisite: Mathematics 305 or consent of instructor.

573-3 **Field and Waves II.** Time-harmonic electromagnetic fields in dielectric and lossy media, transmission lines, antennas and resonators. Techniques include duality, image theory, reciprocity and integral equations. Boundary value problems solved for several frequently encountered symmetries. Prerequisite: 477.

574-3 **Nonlinear Optics.** Coupled-mode-analysis applied to nonlinear wave interactions, harmonic generation, parametric amplification, backward wave amplifiers, backward oscillation in laser systems, phase conjugation and multiple-wave mixing systems, Pockel and Kerr effects, and electro-optical modulations in optical communication systems. Prerequisite: 375 or consent of instructor.

576-3 **Numerical Electromagnetics.** Numerical solution of electromagnetic problems by methods that include finite element, integral equation, moment, spectral domain and finite difference. Examination of electromagnetic problems and their solutions in current literature. Prerequisite: 573.

577-3 **Antenna II.** Analysis, design and CAD of antennas. Numerical methods. Broadband, traveling-wave, frequency independent, electrically-small, aperture and microstrip antenna types. Prerequisite: 472.

578-3 **Digital Image Processing II.** Full-color image processing, image noise and degradation models, image restoration, inverse filtering, Wiener filtering, geometric transformations, image compression models, error-free compression, lossy compression, compression standards, dilation and erosion, opening and closing operations, morphological filtering, boundary descriptors, regional descriptors, principal components, vision-based pattern recognition. Prerequisite: 558.

579-3 **Microwave Engineering II.** Analysis and design of passive and active devices at microwave frequencies. Topics include: power dividers, couplers, filters, ferrite devices, noise, noise effects in detectors, mixers, modulators, amplifier and oscillator design, and an introduction to microwave systems. Prerequisite: 479.

580-1 **Seminar.** Study and formal presentation by student of selected research in electrical engineering. Prerequisite: enrollment in program leading to Master of Science in Electrical Engineering.

581-1 to 3 **Wind Energy Power Systems.** This course introduces graduate students to advanced configurations of wind energy power systems with an in-depth treatment of their control and protection. Wind speeds and power relations, basic design of wind power energy systems, synchronous and induction generators, power inverters, generator drives-control modes, interface with the power grid, system modeling, stability, control and protection. Special approval needed from the instructor.

582-3 **HVDC Transmission.** Development of HVDC technology. Static power conversion. Harmonic elimination. Control of HVDC systems. Interaction between AC and DC systems. Fault development and protection. HVDC systems based on the voltage sourced inverter. Prerequisite: 487 or consent of the instructor.

583-3 **Advanced Applications of Power Electronic Systems.** This course is a sequel of ECE 483 covering several advanced topics and applications in power electronics: State-of-the-art semiconductor devices for high power applications. Phase control and line commutation. Forced commutation, multilevel inverters. Advanced modulation techniques for inverters, harmonic control. Power utility applications: HVDC, FACTS, AC drives and utility interface for wind and solar power systems. Prerequisite: ECE 483 or consent of the instructor.


587-3 Power System Operation and Control. Advanced mathematical and operations research methods applied to power systems such as economic dispatch, unit commitment, transmission losses, control of generation, power pools and power system security. Prerequisite: 488 or consent of instructor.

588-3 Advanced Electrical Network Theory. Graph theory. Steady-state solution of linear and nonlinear networks. Transfer function techniques. Sensitivity analysis for networks. Prerequisite: 484 or consent of instructor.


592-1 to 3 Special Investigations in Electrical Engineering. Individual advanced projects and problems selected by student or instructor. Prerequisite: graduate standing and consent of instructor.

593-1 to 3 Advanced Topics in Electrical Engineering. Lectures on advanced topics of special interest to students in various areas of Electrical & Computer Engineering. This course is designed to offer and test new experimental courses in electrical engineering. (a) Antennas and Propagation, (b) ASIC Design, (c) Communications, (d) Computer Architecture, (e) Control Systems, (f) Design Automation (g) Digital Design (h) Digital Testing and Verification (i) electromagnetic fields and waves (j) Embedded Systems (k) Medical Imaging (l) Mixed-signal testing and design (m) nanotechnology (n) Network systems (o) photonics (p) Physical Design automation (q) Power Electronic Converters and Drive System (r) Power Quality (s) Power System control and protection (t) Renewable Energy (u) RF and Microwave Systems (v) Signal Processing (w) Software Engineering (x) Wireless Systems. Prerequisite: consent of instructor.

595-1 Technical Communications. Engineering communications including resumes, literature reviews, memos, letters, proposals, reports, specifications, user guides and oral presentations. Prerequisite: Graduate standing.

599-1 to 6 Thesis.

600-1 to 24 (1 to 16 per semester) Doctoral Dissertation. Dissertation research. Hours and credit to be arranged by director of graduate studies. Graded S/U only. Prerequisite: Admission to PhD program in Electrical and Computer Engineering.

601-1 per semester Continuing Enrollment. For those graduate students who have not finished their degree programs and who are in the process of working on their dissertation, thesis, or research paper. The student must have completed a minimum of 24 hours of dissertation research, or the minimum thesis, or research hours before being eligible to register for this course. Concurrent enrollment in any other course is not permitted. Graded S/U or DEF only.