Electrical and Computer Engineering
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cecedep@siu.edu

COLLEGE OF ENGINEERING

Graduate Faculty:

Ahmadi, Reza, Assistant Professor, Ph.D., Missouri University of Science and Technology, 2013; 2013. Power electronics, electric drive systems, renewable energy harvesting, and smart grid technologies.


Botros, Nazeih M., Professor and Coordinator of Biomedical Engineering Program, Ph.D., University of Oklahoma, 1985; 1985. Digital hardware design, digital signal processing, digital instrumentation, neural networks, robot sensing, and bioengineering.

Chen, Ying (Ada), Associate 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.


Haniotakis, Themistoklis, Associate Professor, Ph.D., University of Athens, 1990; 1990. Electromagnetics, antenna theory and design, microwaves, microstrip phased arrays and anisotropic materials.

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

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, Jun, Assistant Professor, Ph.D. Duke University, 2008; 2012. Sensors and instrumentation, data acquisition, medical devices, therapeutic ultrasound, haptics.

Ramprasad, Harini, Assistant Professor, Ph.D., North Carolina State University, 2006. Real-Time/Embedded systems, compilers, computer architecture.

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

Tragoudas, Spyros, Professor and Chair, Ph.D., University of Texas at Dallas, 1991;1999. Design and test automation for VLSI, embedded systems, computer networks.

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

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

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

Zhou, Xiangwei, Ph.D., Georgia Institute of Technology, 2011; 2013. Wireless communications, statistical signal processing, cross-layer optimization, cognitive radio, and smart grid.

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, optical 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.

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 ecedept@siu.edu. The Electrical and Computer Engineering home page address is http://engineering.siu.edu/elec/.

**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 the following areas of concentration: Biomedical, Communications, Computers, Control, Electronics, Electromagnetics, Large Scale Integration (VLSI), Networks, Optics, Power, Signal Processing.

**Admission.** For applicants with an M.S. degree, 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 research 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.

For direct and accelerated entry into the Ph.D. program, a Bachelor of Science degree in Electrical or Computer Engineering or a related field with a GPA of 3.2/4 or higher is required. Applications for admission must include the following: A statement of research interest, transcripts, GRE scores, three reference letters and TOEFL score, as required by the Graduate School. Admission to the program is made by the Department Chair upon recommendation by the ECE Graduate Committee.

**Advisement.** The student must always have an advisor while in the program. However, upon arrival, the student may be advised by the department chair. The student must select a committee consisting of three members within the semester of admission. One member will serve as the student’s advisor and also chair the committee. The committee will assist the student in selecting six 500-level ECE courses that define the core and in developing a plan of study. The advisor committee members must be voting ECE faculty members and must meet the requirements of the Graduate school.

**Curriculum.** For applicants with an M.S. degree, the curriculum consists of sixty-two 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 thirty-six hours of dissertation.

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 which has two components: written exam and oral exam. This examination covers the material of the core courses selected and is administered by the student’s advisor. The exam covers at least three major areas of ECE and consists of questions from at least three ECE faculty members (examining committee). The oral exam, conducted by the examining committee, is held within one week of the written exam. 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. The dissertation supervisor must have Direct Dissertation status. A non-ECE faculty member with Direct Dissertation status may serve as a co-Supervisor along with a co-Supervisor who is a regular ECE faculty member with Direct Dissertation status.

**Dissertation Proposal.** Following the admission to candidacy and upon completion of all of 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.

**Comprehensive 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.** The Dissertation must be prepared in accordance to the “Guidelines for Dissertations, Theses and Research Papers” of the Graduate School. Dissertation approval is based on successful defense of the research performed in terms of originality, relevance and presentation (written and oral). This requires approval by at least 80% of the members of the dissertation committee.
**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.

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.

**Graduation.** The student must complete the curriculum with a minimum grade point average of 3.25. For entry with an M.S. degree, a dissertation approved by the committee must be completed within five years after entry.

For direct and accelerated entry, a dissertation approved by the committee must be completed within six years after entry.

The Department has established a timetable for advisement, qualifying examination, candidacy, dissertation committee formation, dissertation proposal, oral examination, and dissertation defense.

**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.

**422-4 Computer Network System Architecture.** Principles of Computer Networks. Protocols and system level implementations. Socket programming, router and switching fabric architecture, security and packet classification techniques, multimedia networking and QoS. Prerequisite: ECE 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 Design of Embedded Systems.** Introduction of modern embedded system application, platform architecture and software development. Principles of embedded processor architecture, operating systems and networking connectivity. Design and optimize in terms of system power, security and performance. Rapid prototyping using Intel-Atom based platform. Lecture and laboratory. Prerequisite: 321 and 329, 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: ECE 329.

**427-4 Integrated Interconnection Networks.** (Same as ECE 527) Importance of interconnection networks and networks-on-chip (NOCs). Specifications and constraints. Topology, routing, flow control, deadlock, livelock, arbitration, allocation, performance analysis, simulation. Prerequisite: ECE 329 or concurrent enrollment.

**428-4 Programmable ASICs Design.** Introduction to theoretical concepts and experimental design and construction of Application-Specific Integrated Circuits (ASICs). Rapid prototyping of data path and control in computer systems. Field Programmable Gate Arrays (FPGAs) or similar logic. Lecture and laboratory. Prerequisite: 329 or consent. Fee of $10 to help defray costs of consumable items.

**429-4 Computer Systems Architecture.** Advanced computer arithmetic, principles of performance evaluation, instruction set principles, pipeline considerations and instruction level parallelism, vector processors, memory hierarchy design. Prerequisite: 329.

**432-4 Programming for Multi-Core Processors.** Multi-core architecture and design, 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: ECE 329, CS 306 or consent of instructor.

**438-3 Medical Instrumentation: Application and Design.** (Same as ECE 538 and BME 538) Basic concept of medical instrumentation, basic sensors and principles, amplifiers, biopotential electrodes, blood pressure and sound, measurement of respiratory system, chemical biosensors, cellular measurement, nervous system measurements, magnetic resonance imaging. Prerequisite: ECE 355.

**440-4 CMOS Radio-Frequency Integrated Circuit Design I.** (Same as ECE 540) Introduction of RF IC, passive RLC Networks, passive IC components, MOS Transistors, distributed systems, Smith Chart and S-Parameters, introduction to Bandwidth estimation, biasing and voltage reference, noise in RF IC, introduction to Amplifiers, Phase-Locked Loops and Oscillators. Lecture and laboratory. Prerequisite: 345, 375; or equivalent.

**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 wide-band, 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 and 355 or concurrent enrollment.
447-4 Electronic Devices. Fundamental principles of semiconductor carrier statistics, band diagrams, pnjunction diodes, Schottky diodes, BJTs, MOS capacitors and MOSFETs for advanced VLSI technology. Lecture and laboratory. Prerequisite: 345, 375 or equivalent.

448-4 Photonics II. Fourier optics, fiber optics, electrooptics, 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 of sampled-data systems, z-transform, digital control design techniques, emulation methods, direct method, industrial applications. Lecture and laboratory. Prerequisite: 315 and 356.

458-3 Digital Image Processing I. (Same as ECE 558) 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: 355 or consent of instructor.

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.

460-3 Principles of Biomedical Engineering. Principles of biomechanics, biomaterials, electrophysiology, modeling, instrumentation, biosignal processing, medical imaging, and biomedical optics. Not for credit towards the BS in Electrical or the BS in Computer Engineering. Prerequisite: ECE 315 and ECE 355.

467-4 Introduction to Biomedical Imaging. (Same as ECE 567 and BME 532) Biomedical imaging. X-ray imaging. Computed tomography (CT). Ultrasound. Magnetic resonance imaging (MRI). Image quality. Image reconstruction. Prerequisite: ECE 355 or consent of instructor.

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. (Same as ECE 575) 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. (Same as ECE 562) 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.

481-3 Wind and Solar Energy Power Systems. (Same as ECE 581) This course introduces students to Wind and solar energy power systems. Planning of wind generation, and operation of wind generators, mechanical and electrical design, power conditioning, control and protection. Planning, operation and design of electric solar plants; power conditioning, control and protection. Prerequisite: ECE 385.

483-4 Electric Drive Systems. (Same as ECE 583) Course content is roughly 1/3 power electronics, 1/3 applied control and 1/3 electric machinery and focuses on analysis, simulation, and control design of electric drive-based speed, torque, and position control systems. Advanced topics depending on the semester are also taught. Prerequisite: ECE 385 and ECE 356, basic knowledge of MATLAB and Simulink (although not required, students are strongly recommended to pass ECE 296 before taking this class).

484-4 Electric and Hybrid Vehicles. (Same as ECE 584) This course covers an entire range of topics related to analysis, design, control, and optimization of electric, hybrid, and plug-in hybrid power trains including automotive applications of adjustable speed motor drives, energy storage systems, and advanced power converters. Prerequisite: ECE 385 or instructor consent.

Electric Energy Generating Plants. Renewable Energy. Special approval needed from the 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. Special approval needed from the 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, queuing theory, switching fabrics, network processors, network systems design tradeoffs. Prerequisite: 422 and 429 or consent of the instructor.

527-3 Integrated Interconnected Networks. (Same as ECE 427) Importance of interconnection networks and networks-on-chip (NOCs). Specifications and constraints. Topology, routing, flow control, deadlock, livelock, arbitration, allocation, performance analysis, simulation. Prerequisite: ECE 329 or equivalent.


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.

530-3 Engineering Data Acquisition. (Same as ENGR 530) Theory of data acquisition and measurement systems. Criteria for selection of data acquisition hardware and software, instruments, sensors and other components of scientific and engineering experimentation. Methods for sampled data acquisition, signal conditioning, interpretation, analysis and error estimation.

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 FPGAAs. 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.

533-3 Speech Processing. (Same as BME 533) Fundamentals of speech production system, signal analysis of speech, speech coding, linear prediction analysis, speech synthesizing, and speech recognition algorithms. Prerequisite: ECE 468 or consent of instructor.

534-3 Modeling and Synthesis of Biological Mechanisms. (Same as BME 536) Mathematical and computer modeling of physiological systems and mechanisms; principal emphasis on cardiovascular system, nerve cells, respiratory system, renal system, and skeletal-muscle system. Prerequisites: PHSL 410A or CHEM 444, or consent of instructor.

535-3 CMOS Radio-Frequency Integrated Circuit Design II. High frequency amplifier design techniques, CMOS low noise amplifiers (LNA), mixers, oscillators, frequency synthesizers, power amplifiers, an overview of wireless architectures. Prerequisite: ECE 540 or equivalent.

536-3 Real-Time Embedded Systems. Introduction to real-time embedded systems. Topics covered include real-time schedulability theory with static and dynamic priority scheduling policies; concepts involved in the design, analysis and verification of real-time systems, including timing and cache analysis; introduction to sensor networks and power-aware scheduling. Prerequisites: ECE 321 and ECE 329.

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

538-3 Medical Instrumentation: Application and Design. (Same as ECE 438 and BME 538) Basic concept of medical instrumentation, basic sensors and principles, amplifiers, biopotential electrodes, blood pressure and sound, measurement of respiratory system, chemical biosensors, cellular measurement, nervous system measurements, magnetic resonance imaging. Prerequisite: ECE 355.

539-3 Diagnostic Ultrasound Physics. (Same as BME 541) Propagation of ultrasonic waves in biological tissues; principles of ultrasonic measuring and imaging instrumentation; design and use of currently available tools for performance evaluation of diagnostic instrumentation; biological effects of ultrasound. Prerequisite: Modern physics, calculus & Fourier analysis or consent of instructor.

540-3 CMOS Radio-Frequency Integrated Circuit Design I. (Same as ECE 440) Introduction to RF IC, passive RLC networks, passive IC components, MOS Transistors, distributed systems, Smith Chart and S-Parameters, introduction to Bandwidth estimation, biasing and voltage reference, noise in RF IC, introduction to Amplifiers, Phase-Locked Loops and Oscillators. Lecture and Laboratory. Prerequisite: ECE 345 and ECE 375.

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: PHYS 320, 328; CHEM 210; or equivalent.


545-3 Advanced Semiconductor Devices. Physical principles and operational characteristics of solid-state devices, p-n junction devices, Interface and thin-film devices, optoelectronic devices, and bulk-effect devices. Fabrication and circuit model of devices. Prerequisite: 447 or consent of instructor.

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. Special approval needed from the instructor.


548-3 Advanced Electronic Devices. A study of techniques in fabricating microelectronic and discrete electronic devices and influence 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. Prerequisites: 447 or 448 or consent of instructor.


551-3 Probability and Stochastic Processes for Engineers. (Same as ECE 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.

551-3 Probability and Stochastic Processes for Engineers. (Same as ENGR 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. Restricted to graduate student status.

552-3 Signal Detection and Estimation. Estimation theory: parameter estimation, minimum variance unbiased estimators, sufficient statistics, Cramer-Rao lower bound, best linear unbiased estimators, maximum likelihood estimators, least squares, Bayesian estimation, maximum a posteriori estimators, minimum mean square error estimators, linear minimum mean square error estimators, Wiener filtering. Detection theory: hypothesis testing, likelihood ratios, Neyman-Pearson detection, Bayesian hypothesis testing, matched filtering, multiple hypothesis testing, sequential detection, composite hypothesis testing, uniformly most powerful tests, generalized likelihood-ratio tests. Prerequisite: ECE 551.


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 transmis-
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. (Same as ECE 467 and BME 532) 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: ECE 355 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. Special approval needed from the instructor.

569-3 Biomedical Instrumentation. (Same as BME 538) Basic concept of Medical instrumentation, basic sensors and principles, amplifiers, biopotential electrodes, blood pressure and sound, measurement of respiratory system, chemical biosensors, Cellular Measurements, Nervous system measurements, magnetic resonance imaging. Prerequisites: PHSL 410A or CHEM 444 or consent of instructor.


571-3 Wireless and Personal Communications Systems. (Same as ECE 471) Introduction to cellular systems. Propagation modeling. Modulation techniques. Digital signaling on fading channels. Diversity and MIMO. OFDM and CDMA. Prerequisite: ECE 315 and ECE 335.

572-3 Neural Networks. Anatomy and physiology of the cerebral cortex. Feed-forward Networks, Linear Associator. Multilayer Perceptrons. Feedback Networks, Hopfield Net-works, ART. Applications to pattern recognition, robotics and speech processing. Optical and electronic implementations. Prerequisite: MATH 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 electrooptical modula-
tions in optical communication systems. Prerequisite: 375 or consent of instructor.

575-3 Antennas I. (Same as ECE 472) Analysis, design, fabrication, measurement and CAD applied to basic antenna types. Fundamental parameters. Friis transmission equation. Imped-
of power system stability, synchronous machine modeling and simulation, transient and small signal stability, control and protection, power system stabilizers, voltage stability, voltage collapse, concepts and devices of flexible ac transmission, midterm and long-term stability. Prerequisite: 487.


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.

589-3 Electric Power Distribution. (Same as ECE 489) Design of primary and secondary distribution networks. Load characteristics. Voltage regulation. Metering techniques and systems. Protecting of distribution systems. Special topics related to power distribution. Prerequisite: ECE 385 or equivalent.

592-1 to 3 Special Investigations in Electrical Engineering. Individual advanced projects and problems selected by student or instructor. Restricted to graduate standing. Special approval needed from the 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) Network systems (o) photonics (p) Physical Design automation (q) Power Electronic Converters and Drive Systems (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. Special approval needed from the instructor.

595-3 Communication Skills for Engineering Graduate Students. This course prepares graduate engineering students to communicate technical information to various audiences and for various purposes. Principles and strategies are applied to theses, dissertations, scholarly presentations, and other engineering documents such as lab reports, user manuals, business correspondences, job application materials, and engineering ethics. Research tools and software programs prepare students to deliver oral presentations on current engineering topics. Restricted to graduate standing. Does not count toward the hours required for graduation in the ECE program.

596-1 Introduction to Biomedical Engineering. (Same as BME 596) Introduction and orientation to the biomedical engineering program. Topics to be discussed include: History and scope of the Program, curriculum, required courses, elective courses, thesis and non-thesis options, graduate committee formation, research areas, monitoring academic progress, financial assis-
tance and discussion of BME-related topics that involve math, chemistry, biology, and engineering. Restricted to: Enrollment in BME or ECE program or instructor consent. Does not count toward the hours required for graduation.

597-1 Biomedical Research Ethics. (Same as BME 597) Series of lectures from distinguished speakers, from academia, industry and government, regarding ethical issues associated with biomedical research and development. Graded S/U or DEF only. Restricted to: Enrollment in BME or ECE program. Does not count toward the hours required for graduation in the ECE program.

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. Restricted to 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.