Electrical and Computer Engineering

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ecedept@siu.edu

COLLEGE OF ENGINEERING

Graduate Faculty:

Ahmed, Shaikh S., Professor, Ph.D., Arizona, 2005; 2007. Nanotechnology, semiconductor devices and circuit design, simulation and characterization.

Anagnostopoulos, Iraklis, Assistant Professor, Ph.D., National Technical University of Athens, 2014; 2015. Many-core architectures, run-time resource management, embedded systems.

Aruma Baduge, Gayan, Assistant Professor, University of Alberta, 2013; 2016. Communications theory, wireless communications, massive MIMO systems, millimeter-wave communications, cooperative relay networks, wireless energy harvesting for IoTs, physical-layer security.

Asrari, Arash, Assistant Professor, Ph.D., University of Central Florida, 2015; 2017. Power systems operation and planning, power systems optimization, smart grid.

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

Chen, Kang, Assistant Professor, Ph.D., Clemson University, 2014; 2015. Software-defined networking (SDN), network function virtualization (NFV), vehicular networks, mobile opportunistic/ad hoc networks.

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

Galanos, Glafkos D., Professor, *Emeritus,* Ph.D., University of Manchester, England, 1970; 1987. Power systems, HVDC transmission, power electronics systems.

Gupta, Lalit, Professor, Ph.D., Southern Methodist University, 1986; 1986. Computer vision, pattern recognition, digital signal processing, neural networks.

Haniotakis, Themistoklis, Associate Professor, Ph.D., University of Athens, 2008; 2013. Digital VLSI design and test, RF IC design and test, low power VLSI design, and fault-tolerant 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, 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.

Komaee, Arash, Assistant Professor, Ph.D., University of Maryland, College Park, 2008; 2015. Control systems, microrobotics, signal processing, estimation theory.

Lu, Chao, Assistant Professor, Ph.D., Purdue University, 2012; 2015. VLSI system design, device-circuit co-design, 3D IC.

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

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

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

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, *Emeritus* 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.

Master of Science (M.S.) in Electrical and Computer Engineering

Objectives. The Master of Science (M.S.) program has two tracks: i) The non-thesis track is coursework-oriented; ii) The thesis track is research oriented and is designed for students who want to pursue research or a Ph.D. degree. The degree (non-thesis/thesis) can be completed in 3-4 semesters.

Admission. Individuals holding a Bachelor's degree in electrical or computer engineering or related field may apply. Qualified applicants with Bachelor's degree 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 M.S. program is based on the following factors: grade point average of 3.0 or higher on a scale of 4.0 on approximately the last 60 semester hours of undergraduate coursework, class ranking, and faculty recommendation letters. GRE scores are not required for admission. However, out-of-state or international students whose GRE Verbal score or Quantitative score percentile is 80% or higher will have the advantage of paying in-state graduate tuition rate. Also, GRE scores, especially Quantitative, may be considered for fellowships/assistantships/scholarships. The Department admission requirements of this program are higher than the minimum requirements of the Graduate School. The minimum TOEFL score requirement for international applicants is 550 (paper based) or 80 (computer based). The program requires a

nonrefundable $65 application fee that must be submitted with the application for Admissions to Graduate Study in Electrical and Computer Engineering. Applicants must pay this fee by credit card.

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 engineering.siu.edu/elec.

Curriculum. The program requires a total of 30 semester hours of graduate-level credit. For the non-thesis track, at least 6 credit hours must be in ECE 500-level courses that are not cross-listed to ECE 400-level courses. ECE 592 and ECE 580 (seminar) will not count towards the degree. For the thesis track, six hours of thesis (ECE 599) are required. A maximum of three hours of ECE 592 could be counted towards the degree requirements. ECE 580 (seminar) will not count towards the degree. Students in this track will develop a program of study in consultation with their thesis advisor/committee. For both non-thesis and thesis tracks, with the approval of the Department, a maximum of 3 online/distance education hours offered by the ECE Department, and a maximum of 6 hours from academic units outside the ECE Department, could be applied towards the degree. Also, note that, for cross-listed courses, graduate students must register for the 500-level equivalent.

Retention. Any student whose cumulative grade point average falls below 3.00 on courses that count towards the degree will be placed on departmental academic probation. Any graduate student on academic probation whose grade point average remains below 3.0 on courses that count towards the degree for two consecutive semesters in which she or he is enrolled, excluding summer sessions, will be permanently suspended from the program, unless the department grants an exception.

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:

- 21 hours of ECE courses, including ECE 599, Master's Thesis (six hours) and ECE 592, Special Investigations (three hours).
- 81 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:

- 21 hours of ECE courses, including ECE 593A-X, Advanced Topics (three hours) and ECE 592, Special Investigations (three hours).
- 81 hours of LAW courses, including nine hours from an approved list of LAW courses.

Nine hours of ECE courses, including ECE 592 and ECE 593A-X 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.

LAW Courses

Consult with the School of Law Associate Dean for Academic Affairs regarding the list of approved LAW courses.

Doctor of Philosophy in Electrical and Computer Engineering

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, Very Large-Scale Integration (VLSI), Networks, Optics, Power Systems, and Signal Processing.

Admission. Individuals holding a Master's degree in electrical or computer engineering or related field with a GPA of 3.25/4.0 or higher may apply. Applications for admission must include the following: a statement of research interest, transcripts, official GRE scores, three reference letters and TOEFL/ IELTS score (where appropriate), as required by the Graduate School.

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 3.20/4.0 or higher is required. Applications for admission must include the following: a statement of research interest, transcripts, official GRE scores, three reference letters and TOEFL score,

as required by the Graduate School.

Advisement. 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.

Retention. Any graduate student whose cumulative grade point average falls below 3.25 on courses that count towards the degree will be placed on departmental academic probation. Any graduate student on academic probation whose grade point average remains below 3.25 on courses that count towards the degree for two consecutive semesters in which she or he is enrolled, excluding summer sessions, will be permanently suspended from the program, unless the department grants an exception.

Curriculum. For applicants with a Master's degree, the curriculum consists of 50 hours of credit beyond the Master's degree, of which 26 credit hours must be at the 500/400 level and 24 are dissertation hours. 12 hours of ECE 500-level courses that are not cross-listed to 400-level courses, of which 9 hours must be taken from the selected core, 3 hours of mathematics or science or other engineering, and 2 hours of ECE seminar are required. A maximum of 3 hours of ECE 592 and 2 hours of ECE seminar could be counted towards the degree requirements. A maximum of 6 hours from academic units outside the ECE Department could be counted towards the degree requirements. The courses from academic units outside the ECE Department must be approved by the student's Committee and the Department. With the approval of the Department, a maximum of 3 online/distance education hours offered by the ECE Department could be applied towards the degree. 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 12 hours of 500-level ECE courses beyond the M.S. degree. Also, note that, for cross-listed courses, graduate students must register for the 500-level equivalent.

For direct and accelerated entry into the Ph.D. program, the curriculum consists of 80 hours of credit beyond the B.S. degree, of which 56 credit hours must be at the 500/400 level and 24 are dissertation hours. 24 hours of ECE 500-level courses that are not cross-listed to 400-level courses, of which 9 hours must be taken from the selected core, 3 hours of mathematics or science or other engineering, and 2 hours of ECE seminar are required. A maximum of 9 hours of ECE 592 and 2 hours of ECE seminar could be counted towards the degree requirements. A maximum of 9 hours from academic units outside the ECE Department could be counted towards the degree requirements. The courses from academic units outside the ECE Department must be approved by the student's Committee and the Department. With the approval of the Department, a maximum of 3 online/distance education hours offered by the ECE Department could be applied towards the degree. Also, note that, for cross-listed courses, graduate students must register for the 500-level equivalent.

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. Prior to taking the exam, the student must form an examining committee comprised of three voting ECE faculty members or two voting ECE faculty members and the ECE chair. The written examination covers at least three major areas of ECE and consists of questions from each member of the examining committee. The oral exam, conducted by the student's examining committee, is held within two weeks of the written exam. The student should score at least 75 percent in each area tested and must satisfactorily answer the questions in the oral exam. If not successful, the committee may allow the student to repeat the whole or part of the examination. The qualifying examination, in whole or in part, cannot be taken more than two times. The written exam, which is administered by the ECE Graduate Affairs Committee, is offered in the second week of February and the second week of September.

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 24 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 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 percent 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 on courses that count towards degree. 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 but only up to 6 hours.

ECE 429-3 Computer Systems Architecture. (Same as ECE 529) Principles of performance evaluation, processor microarchitecture, instruction-level parallelism, static and dynamic pipeline considerations. Superscalar processors. Multiprocessor systems. Memory hierarchy design, cache design. Mutual exclusion and synchronization mechanisms. Prerequisite: ECE 329 with a grade of C or better.

ECE 459-3 MEMS and Micro-Engineering. Introduction to micro-electro-mechanical systems (MEMS), manufacturing techniques, microsensors, microactuators, microelectronics and micro-controllers. Lecture and laboratory. Prerequisite: ECE 315 and ECE 356.

ECE 468B-3 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. Restricted to graduate standing. Lab fee: $20 to help defray cost of software licenses.

ECE 477-3 Fields and Waves I. Transmission lines for communications. Guided wave principles and resonators. Applications in electronics, optoelectronics and photonics. Principles of radiation. Solution techniques for Laplace's equation and one-dimensional wave equation. Prerequisite: ECE 375.

ECE 486-3 Clean Electric Energy. History and future of energy resources and their use as a component of electrical systems. Fossil fuels and renewable energy sources. Environmental and economical impacts of various energy sources. Electric energy generating plants and distributed generation. Design of hybrid renewable energy systems. Prerequisite: ECE 385 with a grade of C or better.

ECE 487-3 Power Systems Analysis. Modeling and analysis of electric power systems. Topics covered: ac power, generators, power transformers, transmission line parameters and steady state operation, computation of power flows. The course uses power system analysis software. Lecture. Prerequisite: ECE 385 with a minimum grade of C.

ECE 512-3 Wireless Networks. (Same as ECE 412) Compared to infrastructure based wireless communication systems, ad hoc wireless networks present several unique advantages. Thus, it has been widely studied as an important wireless communication paradigm. This graduate level course first introduces several widely adopted wireless communication technologies and then presents the concept, structure, and principles of ad hoc wireless networks. The course also introduces the details of several popular ad hoc wireless networks including mobile ad hoc networks, delay tolerant networks, wireless sensor networks, and connected vehicle networks. Novel applications in those networks will also be introduced. The course work will include paper and literature review, presentations, assignments, and a project that will enable students to be familiar with ad hoc wireless networks. NS2 will be used for student project in this course. Students can gain experience on NS2. Project-based fee: $10 to help defray cost of equipment.

ECE 513-3 Digital VLSI Design. (Same as ECE 423) 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. Restricted to enrollment in ECE program. Project-based fee: $35 to help defray cost of software licenses and equipment.

ECE 514-3 Design of Embedded Systems. (Same as ECE 424) 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. Project-based fee: $10 to help defray cost of equipment.

ECE 515-3 Three Dimensional Integration Systems. This course introduces the design of three dimensional VLSI integration systems, including through-silicon-via (TSV) process, characterization and modeling, 3D IC systems design, mixed signal simulation, data management, testing, process, variation, thermal and reliability challenges, as well as review of 3D system design examples. Laboratory experience in design tools (Cadence Virtuoso and Liberate, AMS simulator). Prerequisite: ECE 345 and ECE 423 with a grade of C or better. Restricted to enrollment in ECE program.

ECE 516-3 Implementation of VLSI Systems with HDL. (Same as ECE 426) This course is dedicated for advanced Digital VLSI architecture and system implementation for high performance and low power digital signal processing applications. Application-specific processors and architectures to support real time processing of signal processing systems will be studied. Hands-on experience of using state-of-the-art CAD tools on designing such kind of VLSI architecture and systems. Upon completion of this course, students will entail large HDL-based implementation of a complete VLSI system. Prerequisite: ECE 327 with a grade of C or better. Project-based fee: $35 to help defray cost of software licenses and equipment.

ECE 520-3 VLSI Design and Test Automation. (Same as

ECE 425) 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 with a C or better or consent of instructor. Restricted to enrollment in ECE program. Project-based fee: $30 to help defray cost of software licenses and equipment.

ECE 521-3 Fault-Tolerant Computer Design. Concepts of error detection, location and correction in digital systems. Codes for error detection and correction. Models and simulations of faults. Design of tests for combinatorial and sequential circuits. Testability. Design of digital systems with testability. Prerequisite: ECE 423, ECE 425 or consent of instructor. Restricted to enrollment in ECE program.

ECE 522-3 VLSI Circuit Testing. Theoretical and practical aspects of production testing of VLSI circuits. Relations between physical defects and fault models. Procedures for generating test inputs. Design modifications for test application and theory of built-in self-test. Prerequisite: ECE 425 or ECE 520 with a minimum grade of C or consent of instructor. Restricted to enrollment in ECE program. Project-based fee: $25 to help defray cost of software licenses.

ECE 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: ECE 423 or ECE 513 with a minimum grade of C or consent of instructor. Restricted to enrollment in ECE program. Project-based fee: $35 to help defray cost of software licenses and equipment.

ECE 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: ECE 425 or ECE 520 with a minimum grade of C or consent of instructor. Restricted to enrollment in ECE program. Project-based fee: $35 to help defray cost of software licenses and equipment.

ECE 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. Floor planning, 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: ECE 425 or ECE 520 with a minimum grade of C or consent of instructor. Restricted to enrollment in ECE program. Project-based fee: $35 to help defray cost of software licenses and equipment.

ECE 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: ECE 422 and ECE 429 or consent of the instructor. Restricted to enrollment in ECE program.

ECE 527-3 Integrated Interconnection Networks. Importance of interconnection networks and networks-on-chip (NOCs). Specifications and constraints. Topology, routing, flow control, deadlock, livelock, arbitration, allocation, performance analysis, simulation. Restricted to enrollment in ECE program.

ECE 528-3 Programmable ASIC Design. (Same as ECE 428) Principle and practice of designing and implementing Application-Specific Integrated Circuits (ASIC). Field Programmable Gate Arrays (FPGA). Timing analysis, timing closure and managing difference clock domains in ASIC design. Complex arithmetic circuits. Digital signal processing (DSP) circuits. FPGA microprocessors. Project-based fee: $50 to help defray cost of equipment and consumable items.

ECE 529-3 Computer Systems Architecture. (Same as ECE 429) Principles of performance evaluation, processor microarchitecture, instruction-level parallelism, static and dynamic pipeline considerations. Superscalar processors. Multiprocessor systems. Memory hierarchy design, cache design. Mutual exclusion and synchronization mechanisms. Restricted to enrollment in ECE program.

ECE 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. Restricted to enrollment in ECE program. Project-based fee: $60 to help defray cost of software licenses and equipment.

ECE 531-3 Mixed-Signal VLSI Design. Analysis and design of mixed-signal integrated circuits. Digital to analog converter (DAC). Analog to digital converter (ADC). Sigma-delta data converters. Performance analysis of signal chains containing both analog and digital signal processing functions. Prerequisite: ECE 446 with a minimum grade of C. Restricted enrollment in ECE program. Project-based fee: $60 to help defray cost of software licenses and equipment.

ECE 532-3 Programming Parallel Processors. (Same as ECE 432) 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. Restricted to ECE students or consent of advisor. Project-based fee: $20 to help defray cost of equipment.

ECE 533-3 Speech Processing. (Same as BME 533, ECE 474) Fundamentals of speech production system, signal analysis of speech, speech coding, linear prediction analysis, speech synthesizing, and speech recognition algorithms. Prerequisite: MATH 250, ECE 355 with grades of C or better or consent of instructor.

ECE 534-3 Biomedical Signal Analysis. (Same as ECE 498, BME 536) The nature of biomedical signals. Electricity in living tissue. Biomedical signal processing and modeling. Modeling and simulation of biomedical systems. Prerequisite: MATH 250, ECE 355 with a grade of C or better or consent of instructor. Project-based fee: $20 to help defray cost of software licenses.

ECE 535-3 CMOS Radio-Frequency Integrated Circuit Design. (Same as ECE 440) Introduction of RF IC, passive RLC Networks, passive IC components, MOS Transistors, distributed systems, Smith Chart and S-Parameters, introduction to Band-

width estimation, biasing and voltage reference, basic High Frequency Amplifiers, introduction to: noise in RF IC, Low Noise Amplifiers, Power Amplifiers, Phase-Locked Loops and Oscillators. Lecture and laboratory. Lab fee: $35 to defray the cost of software licenses and equipment.

ECE 536-3 Many-Core Embedded Systems. Advanced software concepts and techniques to develop complex software projects. Concepts and techniques include advanced dynamic memory management, cross-compilation issues, scheduling techniques and resource management.

ECE 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. Restricted to enrollment in ECE program.

ECE 538-3 Medical Instrumentation: Application and Design. (Same as ECE 438 and BME 538) This course introduces basic concept of medical instrumentation, basic sensors and principles, amplifiers, biopotential, and applications to biopotential measurements. The course will focus on application and design of medical instrumentations. The course also will introduce biosensor, biomedical signal processing, and other related topics. Prerequisite: MATH 250 with a grade of C or better, or consent of instructor. Project-based fee: $45 to help defray cost of software licenses and equipment.

ECE 539-3 Diagnostic Ultrasound. (Same as ECE 494 and BME 541) Diagnostic ultrasound is an ultrasound-based biomedical imaging technique used to visualize muscles, tissue, and many internal organs, to capture their size, structure and any pathological lesions. This course is an introduction to the principles and applications of biomedical ultrasound. This course will focus on fundamentals of acoustic theory, principles of ultrasonic detection and imaging, design and use of currently available tools for performance evaluation of diagnostic devices, and biological effects of ultrasound. Prerequisite: MATH 250 with a grade of C or better, or consent of instructor. Project-based fee: $30 to help defray cost of software licenses and equipment.

ECE 540-3 CMOS Radio-Frequency Integrated Circuit Design II. High frequency amplifier design techniques, noise in RF IC and CMOS low noise amplifiers (LNA), mixers, oscillators, PLLs, frequency synthesizers, power amplifiers, an overview of wireless architectures. Prerequisite: ECE 440 or ECE 535 or equivalent. Lab fee: $50 to defray the cost of software licenses and equipment.

ECE 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. Restricted to enrollment in ECE program.

ECE 542-3 Photonics I. (Same as ECE 441) Ray optics, wave optics, beam optics, polarization of light, statistical optics, photons and atoms. Prerequisite: ECE 375 with a grade of C or better. Project-based fee: $50 to help defray cost of equipment and consumable items.

ECE 543-3 Advanced Analog Integrated Circuit Design. Analysis and design of CMOS analog integrated circuits. Circuit noise analysis. Low-voltage high-performance operational amplifiers. Voltage and current reference circuits. Integrated analog filter circuits. Micropower circuits. Prerequisite: ECE 446 or ECE 546 with a minimum grade of C or consent of instructor. Restricted to enrollment in ECE program. Project-based fee: $35 to help defray cost of software licenses and equipment.

ECE 544-3 Photonics II. (Same as ECE 448) Fourier optics, fiber optics, electro-optics, nonlinear optical media, acousto-optics, photonic switching, optical and interconnections and optical storage. Prerequisite: ECE 441 or consent of instructor. Project-based fee: $80 to help defray cost of software licenses.

ECE 545-3 Advanced Semiconductor Devices. Technology drivers: Moore, More-Moore, and More-than-Moore trends. Case Study: Integrated health monitoring systems, 3-D SoCs. Review of Solid-State Theory: electronic, magnetic, optical and thermal properties of semiconductors. Energy Related Devices: solid-state lighting, solar cells, thermoelectric devices, piezoelectric devices, energy storages and supercapacitors. Optoelectronic and Photonic Devices: Imagers, LEDs, OLEDs, Lasers, LCDs, thin-film transistors (TFTs). Sensors and Detectors. Microwave and Terahertz Devices. Prerequisite: ECE 447 or ECE 423 or ECE 446 or PHYS 425 or PHYS 430 or instructor consent.

ECE 546-3 Analog Circuit Design. (Same as ECE 446) Analysis and design of electronic circuits, both discrete and integrated. Computer-aided circuit design and analysis. Design of amplifier and filter circuits. Circuit stability analysis and frequency compensation techniques. Restricted to enrollment in ECE program. Project-based fee: $10 to help defray cost of equipment.

ECE 547-3 Semiconductor Devices. (Same as ECE 447) Semiconductor industry and Moore's law. Review of quantum mechanics of atoms. From atoms to crystals: energy bands, effective mass and density-of-states. Semiconductor statistics. Carrier transport phenomena. PN junctions. Schottky junctions. Bipolar junction transistors (BJTs). MOSFETs: capacitance-voltage and current-voltage characteristics, threshold voltage, scaling and short-channel effects, SPICE models. CMOS process integration. Basic optoelectronic devices: LEDs and solar cells. Lecture and laboratory. Prerequisite: ECE 345 or equivalent. Project-based fee: $25 to help defray cost of software licenses.

ECE 548-3 Quantum Phenomena and Devices. Introduction: Classical Phenomena and Devices. Why Quantum Devices? Current Picture: Academia and Industry. Essential Statistical Mechanics. Essential Quantum Mechanics. Quantum Theory of Electrons: Quantization, Tunneling, Quantum Interference, Quantum Hall Effect, Scattering and Broadening, Dephasing and Shot Noise. Coulomb Blockade. Quantum Optics. Collective Phenomena and Spin. Relativistic Quantum Phenomena. Quantum Phase Transition. Quantum Computation. Prerequisite: ECE 447 or ECE 423 or ECE 446 or PHYS 425 or PHYS 430 with C or better or instructor consent.

ECE 549-3 Fiber Optic Communications. 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: ECE 447 or ECE 448 or consent of instructor. Restricted to enrollment in ECE program.

ECE 550-3 Nanoscale VLSI Devices. Review of fundamental principles of semiconductor devices. NanoTransistor: Charge-based devices-MOSFETs, non-ideal, atomistic, and quantum effects in nanoscale MOSFETs, charge-coupled devices. Advanced MOSFETs: FinFETs, SOI, SiGe and III-Vs, carbon nanotubes, graphene and 2-D semiconductors, nanowires. High electron mobility transistors (HEMTs), HBTs, and power MOSFETs. Compact and SPICE models for MOS devices. VLSI interconnects, parasitic elements, 3-D integration and reliability issues. Non-charge based devices-tunnel FETs, spin-based devices. NanoMemory: EEPROM and Flash, phase change memory, memristors, magnetic and ferroelectric, spin-torque devices, DRAM and ZRAM cells. TCAD simulation of semiconductor devices. Prerequisite: ECE 447 or ECE 423 or ECE 446 or PHYS 425 or PHYS 430 with a C or better or instructor consent. Project-based fee: $25 to help defray cost of software licenses.

ECE 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. Restricted to enrollment in ECE program. Project-based fee: $20 to help defray cost of software licenses.

ECE 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 hyposthesis testing, sequential detection, composite hypothesis testing, uniformly most powerful tests, generalized likelihood-ratio tests. Prerequisite: ECE 551 or consent of instructor. Restricted to enrollment in ECE program.

ECE 553-3 Computer Network System Architecture. (Same as ECE 422) 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. Restricted to enrollment in ECE program. Project-based fee: $10 to help defray cost of equipment.

ECE 554-3 Broadband Wireless Communications. This course covers fundamentals of broadband wireless communications. Topics include concepts of space-time propagation, probabilistic modeling of space-time channel and signal models, multi-antenna (MIMO) systems, space-time coding, spatial diversity, spatial multiplexing, space-time receivers, orthogonal frequency division multiplexing (OFDM), MIMO OFDM, multi-user MIMO, performance analysis and trade-offs in MIMO channels, concepts of spread spectrum systems, frequency hopping, and direct sequence systems. Restricted to enrollment in ECE program or consent of instructor.

ECE 555-3 Introduction to Information Theory and Channel Coding. (Same as ECE 476) Entropy and Mutual Information. Channel Capacity. Gaussian Channel. Linear Block Codes. Convolutional Codes. Advance Channel Coding Techniques. Restricted to enrollment in ECE program.

ECE 556-3 Digital Communications. Digital communication signals and systems characterization. Deterministic receiver design. Probabilistic receiver design. Error control coding. Communication over band limited channels. Prerequisite: ECE 551 or consent of the instructor. Restricted to enrollment in ECE program.

ECE 557-3 Computational Electronics. Elements of computational science/engineering. High-performance clusters and software tools for HPCs. Essential numerical methods. Fundamental physics and modeling of charge transport in semiconductor VLSI devices. Numerical solution of Poisson equation. Numerical solution of carrier continuity equations and terminal currents in semiconductor devices. Numerical solution of the Schrodinger equation. Electronic bandstructure calculations using the tight-banding formalism. Introduction to NEGF formalism. Commercial and non-commercial semiconductor device modeling tools. Prerequisite: ECE 447 or PHYS 425 with grades of C or better or instructor consent. Project-based fee: $25 to help defray cost of software licenses.

ECE 558-3 Digital Image Processing I. (Same as ECE 458) 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. Special approval needed from the instructor. Restricted to enrollment in ECE program.

ECE 560-3 VLSI Material and Device Characterization. Materials for modern VLSI: semiconductor crystals, tubular and monolayer materials, organic materials, heterostructures, wafers and notations. Nanoscale fabrication processes: IC production flow, selective doping, nanolithography, etching, contacts and interconnects, spontaneous formation and ordering of nanostructures, fabrication of MEMS/NEMS systems, IC assembly and packaging. VLSI device characterization: electrical CV and IV profiling, defect characterization using DLTS, carrier mobility and lifetime measurements, optical microscopy and spectroscopy, particle beam and X-ray techniques. Reliability of devices and ICs: harsh environments, hot carriers, NBTI, electromigration, electrostatic discharge, IC power dissipation and cooling. Prerequisite: ECE 447 or ECE 423 or PHYS 425 with a grade of C or better or instructor consent.

ECE 561-3 Mechatronics and Embedded Control. (Same as ECE 456) Components of mechatronics systems, mathematical modeling, system identification, numerical tools for design and analysis, single-loop controller design, embedded systems, data acquisition and signal conditioning, sensors, actuators, networked control. This course includes lab session. Lab fee: $35 to help defray the cost of software licenses.

ECE 562-3 Microwave Engineering I. (Same as ECE 479) 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: ECE 375 or equivalent. Restricted to enrollment in ECE program. Project-based fee: $100 to help defray cost of software licenses.

ECE 564-3 Optimal Control. Optimization techniques for linear and nonlinear systems. Variational calculus. Dynamic programming. Pontryagin's maximum principle. Hamilton-Jacobi theory. Linear regulator. Bang Bang control, minimum time control, singular control. Discrete variational calculus. Combined estimation and control. Computational methods in optimal control. Prerequisite: ECE 456 or consent of instructor. Restricted to enrollment in ECE program.

ECE 565-3 Nonlinear Control Systems. Analysis and design of nonlinear dynamical systems. Topics include: nonlinear differential equations, stability, Lyapunov stability analysis, stability of perturbed systems, linearization, and central manifold theorem. Stabilization, feedback linearization, and controller design methods such as backstepping and sliding mode control.

ECE 566-3 Linear Systems Theory. Introduction to the structure and analysis of linear dynamical systems in time domain. Linear algebra review, solutions of linear differential equations, state-space representations, state transition matrix, and time varying systems. Introduction to fundamental mathematics of linear spaces and linear operator theory. Structural properties of linear systems such as controllability, observability, and stability. Design and synthesis of controllers and state observers for linear systems. Linear quadratic regulatory theory and Kalman filter.

ECE 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. Restricted to enrollment in ECE program. Project-based fee: $30 to help defray cost of software licenses and equipment.

ECE 568-3 Introduction to Machine Learning for Engineering Applications. Introduction: Basic concepts, Model selection and feature selection, Performance metrics and validation techniques, Probability and statistics review. Supervised learning: Bayes decision theory, Naive Bayes classifier, Mahalanobis distance classifier, Minimum distance classifier, Maximum-likelihood parameter estimation, Nearest neighbor classifiers, Logistic regression, Hidden-Markov models, Support vector machines, Bagging, Boosting, Ensemble classifiers. Unsupervised Learning: Clustering: K-means, Hierarchical, Expectation-maximization. Dimensionality Reduction: Principal components analysis, transform techniques. Restricted to Senior or graduate standing.

ECE 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. Restricted to enrollment in ECE program. Lab fee: $45 to help defray cost of software licenses and equipment.

ECE 570-3 Principles of Communication Systems. (Same as ECE 478) This course covers principles of communication systems. Topics include (1) representation of signals and systems, (2) amplitude modulation, (3) angle modulation, (4) probability theory and random processes for communication system designs, (5) transition from analog to digital and pulse code/delta modulation, (6) baseband digital transmission, (7) digital band-pass transmission techniques, (8) introduction to information theory and coding, (9) wireless channel modeling, (10) cellular systems and performance analysis. Lectures and laboratory projects. Prerequisites: ECE 315 and ECE 355 or consent of instructor. Restricted to enrollment in ECE program or consent of instructor.

ECE 571-3 Advanced Wireless Communication. This course covers advanced topics in wireless communications. Topics include wireless system architectures, wireless channel modeling, cellular systems and co-channel interference, advanced digital modulation and multiple-access techniques, massive MIMO, mm-wave communications, performance analysis, radio resource allocation and optimization, wireless physical layer security, enabling technologies for 5G. Restricted to enrollment in ECE program or consent of instructor. Project-based fee: $20 to help defray cost of software licenses.

ECE 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: MATH 305 or consent of instructor. Restricted to enrollment in ECE program.

ECE 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: ECE 477. Restricted to enrollment in ECE program.

ECE 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: ECE 375 or consent of instructor. Restricted to enrollment in ECE program.

ECE 575-3 Antennas I. (Same as ECE 472) 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: ECE 375 or equivalent. Restricted to enrollment in ECE program. Project-based fee: $120 to help defray cost of software licenses.

ECE 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: ECE 573. Restricted to enrollment in ECE program.

ECE 577-3 Antennas II. Analysis, design and CAD of antennas. Numerical methods. Broadband, traveling-wave, frequency

independent, electrically-small, aperture and microstrip antenna types. Prerequisite: ECE 472. Restricted to enrollment in ECE program.

ECE 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: ECE 558. Restricted to enrollment in ECE program.

ECE 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: ECE 479. Restricted to enrollment in ECE program.

ECE 580-1 Seminar. Study and formal presentation by students of selected research in electrical and computer engineering. Restricted to students in the graduate program in Electrical and Computer Engineering. Special approval needed from the instructor.

ECE 581-3 Wind and Solar Energy Power Systems. (Same as ECE 481) The 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.

ECE 582-3 Power Converter Design and Control. (Same as ECE 482) This course covers all the steps required for designing an actual power converter or electric drive system. The power stage design considerations, gate drive circuits, isolated high voltage/current measuring circuits, and application of a Texas Instrument Digital Signal Processor (DSP) for implementing different control schemes are discussed in detail. A brief introduction about the digital control theory and implementation of digital controller transfer functions using the DSP are provided as well. Project-based fee: $65 to help defray cost of software licenses and equipment.

ECE 583-3 Electric Drive Systems. (Same as ECE 483) 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 taught. Project-based fee: $65 to help defray cost of software licenses and equipment.

ECE 584-3 Electric and Hybrid Vehicles. (Same as ECE 484) 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. Restricted to enrollment in ECE program or consent of the instructor. Lab fee: $65 to help defray cost of software licenses and equipment.

ECE 585-3 Power Systems Stability and Control. Fundamentals 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, mid-term and long-term stability.

ECE 586-3 Computational Methods in Power Systems. The course covers advanced methods for the computation and analysis of power systems. Topics: circuit graph theory and network matrices, computation of electromagnetic transients, computation of power flows and faults, computation of system stability, stochastic methods in power systems, load forecasting, state estimation, unit dispatch. The course uses power system software. Lecture. Restricted to enrollment in the ECE program.

ECE 587-3 Modern Power Systems Operation. This course provides students with a comprehensive picture of the techniques used in modern power systems operation. The course introduces central "terminal" characteristics for thermal and hydroelectric power generation systems, along with new optimization techniques for tackling "real-world" power systems operating problems. The topics include: analysis of different bidding strategies in competitive electricity markets, prediction of load and price, analysis of power systems security, different methods of optimal power flow, analysis of power systems uncertainty and reliability, economic dispatch, and unit commitment analysis. Project-based fee: $65 to help defray cost of software licenses and equipment.

ECE 588-3 Power System Engineering. (Same as ECE 488) The course covers topics involving the design and operation of a power system. Topics: symmetrical and unsymmetrical power system faults, power system protection design, transient stability of power generators, power system economic operation, power system control, transient operation of transmission lines. The course uses power system software. Lecture.

ECE 589-3 Electric Power Distribution. (Same as ECE 489) Design of primary and secondary distribution networks. Load characteristics. Voltage regulation. Metering techniques and systems. Protection of distribution systems. Special topics related to power distribution. Prerequisite: ECE 235.

ECE 592-1 to 3 Special Investigations in Electrical Engineering. Individual advanced projects and problems selected by student or instructor. Restricted to graduate standing. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593A-1-3 Advanced Topics in Electrical Engineering-Antennas and Propagation. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593B-1-3 Advanced Topics in Electrical Engineering-ASIC Design. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593C-1-3 Advanced Topics in Electrical Engineering-Communications. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593D-1-3 Advanced Topics in Electrical Engineering-Computer Architecture. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593E-1-3 Advanced Topics in Electrical Engineering-Control Systems. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593F-1-3 Advanced Topics in Electrical Engineering-Design Automation. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593G-1-3 Advanced Topics in Electrical Engineering-Digital Design. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593H-1-3 Advanced Topics in Electrical Engineering-Digital Testing and Verification. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593I-1-3 Advanced Topics in Electrical Engineering-Electromagnetic Fields and Waves. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593J-1-3 Advanced Topics in Electrical Engineering-Embedded Systems. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593K-1-3 Advanced Topics in Electrical Engineering-Medical Imaging. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593L-1-3 Advanced Topics in Electrical Engineering-Mixed-Signal Testing and Design. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593M-1-3 Advanced Topics in Electrical Engineering-Nanotechnology. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593N-1-3 Advanced Topics in Electrical Engineering-Network Systems. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593O-1-3 Advanced Topics in Electrical Engineering-Photonics. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593P-1-3 Advanced Topics in Electrical Engineering-Physical Design Automation. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593Q-1-3 Advanced Topics in Electrical Engineering-Power Electronic Converters and Drive Systems. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593R-1-3 Advanced Topics in Electrical Engineering-Power Quality. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593S-1-3 Advanced Topics in Electrical Engineering-Power System Control and Protection. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593T-1-3 Advanced Topics in Electrical Engineering-Renewable Energy. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593U-1-3 Advanced Topics in Electrical Engineering-RF and Microwave Systems. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593V-1-3 Advanced Topics in Electrical Engineering-Signal Processing. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593W-1-3 Advanced Topics in Electrical Engineering-Software 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 593X-1-3 Advanced Topics in Electrical Engineering-Wireless Systems. 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 ECE. Restricted to enrollment in ECE program. Special approval needed from the instructor.

ECE 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. Restricted to enrollment in ECE program.

ECE 596-3 Principles of Biomedical Engineering. (Same as ECE 460, BME 596) Principles of biomechanics, biomaterials, electrophysiology, modeling, instrumentation, biosignal processing, medical imaging, and biomedical optics. Professional moral and ethical issues in biomedical research and development. Prerequisite: MATH 250 with a grade of C or better or consent of instructor.

ECE 599-1 to 6 Thesis.

ECE 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.

ECE 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.