Department of Electrical and Computer Engineering

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Adjunct Graduate Faculty: Peter Tay

Graduate Degrees Offered

- Doctor of Philosophy in Electrical and Computer Engineering
- Master of Science in Computer Engineering
- Master of Engineering in Computer Engineering
- Master of Science in Electrical Engineering
- Master of Engineering in Electrical Engineering

Doctor of Philosophy in Electrical and Computer Engineering

Doctoral Program Coordinator: John Chiasson
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General Information

Boise State University offers a Doctor of Philosophy in Electrical and Computer Engineering through the Department of Electrical and Computer Engineering (ECE). The degree requires the completion of a prescribed course of study in ECE, satisfactory performance on the comprehensive examination and dissertation proposal, and independent completion of original research that results in a publicly defended dissertation that contributes significantly to ECE knowledge. Please refer to the "Regulations for the Doctor of Philosophy Programs" in the front section of the catalog.

Graduate Teaching and Research Fellowships

Graduate fellowships including tuition and fee waivers are funded from three sources: appropriated state funds, endowments, and research grants and contracts. Applicants to the Ph.D. in ECE program who submit all documents required by the admission procedure by February 1 of any given year will be considered for a state appropriated or endowed graduate fellowship to start the following fall semester; notification of successful applicants will occur in February and March. Information on graduate fellowships funded by research grants and contracts is available from the Coordinator of the ECE doctoral program.

Doctoral Program Committee

The Doctoral Program Committee in ECE consists of the ECE Doctoral Program Coordinator, the program coordinators for the electrical engineering and computer engineering Master's programs, and the associate chair of the department. The duties of the Doctoral Program Committee include development of recommendations for admission of prospective graduate students, decision on transfer credits and required background courses, appointment of Supervisory Committees for graduate students, and administration of the comprehensive examination.

Supervisory Committee

The Supervisory Committee is charged with general guidance of the doctoral student, including design and approval of the program of study, administration of the oral dissertation proposal, supervision of the dissertation research, and participation in dissertation defense. The Supervisory Committee consists of a principal advisor from the student's chosen area of major emphasis who acts as chair, one member from the student's chosen area of minor emphasis, and at least two additional members, all of whom must be members of the University regular or research faculty and must also be members of the Graduate Faculty. One or more additional members may be appointed when such appointments enhance the function of the Committee. In all cases, regular or research faculty members of the Department of Electrical and Computer Engineering must constitute a majority of the Supervisory Committee.

Application and Admission Requirements

Admission Requirements An applicant must satisfy the minimum admission requirements for the Graduate College. Applicants are required to have a Bachelor's or Master's degree in electrical engineering or computer engineering from an ABET-accredited program or a baccalaureate or Master's degree in a closely related field from an accredited college or university, and must follow the application procedures specified below. Admission is competitive and the achievement of minimum requirements does not guarantee admission into the program.

Application Procedures A prospective student may apply at any time and should follow the general graduate application procedure for degree-seeking students (see Applying as a Degree-Seeking student in this catalog). Applications received by February 1 will received full consideration for departmental Fellowships and Teaching Assistantships. Admission to the program will be based on: 1) transcripts, 2) professional references, preferably three, 3) scores on the general test of the Graduate Record Examination (GRE), and 4) a two-page statement of teaching and research interests. Students whose native language is not English must submit a TOEFL score of 587 or higher for the written examination or 95 Internet-based (iBT) examination. Test scores must be submitted directly to Boise State University (code R4018). Once the applicant's file is complete, it will be evaluated by the ECE Doctoral Program Committee and an admission recommendation (regular, provisional, or denial) will be forwarded to the Dean of the Graduate College. In order to ensure proper mentoring of all graduate students, a recommendation for admission will not be forwarded unless a faculty member in ECE is available to serve as the major advisor. The graduate dean will make the final admission decision and notify the applicant and the ECE Doctoral Program Committee.

Degree Requirements

The program of study for the Doctor of Philosophy (Ph.D.) in Electrical and Computer Engineering will require at least 72 credits beyond the Bachelor's Degree or 48 credits beyond a Master's Degree, and adhere to all policies and procedures of the Graduate College. Courses applied to meet the 72-credit minimum requirement must be taken for a letter grade (A-F), except for ECE 600 Assessment which is graded P (Pass) or F (Fail), and ECE 693 Dissertation which is initially graded IP (In Progress) and later graded P or F depending on the outcome of the dissertation defense. Credit for coursework must be distributed as shown in the degree requirements table. For those entering the program with a Master's Degree, no more than 24 credits of previous graduate coursework can be applied as course credit. For a student entering with a Bachelor's degree, a maximum of 9 credits of post graduate coursework can be applied towards the Ph.D. program. All programs of study must be approved by the student's Supervisory Committee.

Doctor of Philosophy in Electrical and Computer Engineering	
Course Number and Title	**Credits**
Core Sequence ENGR 500 Research Methods ..... 1 **At least 3 courses from the following** ECE 500 Applied Electromagnetics ..... 3 ECE 510 Integrated Circuit Physical Design ..... 3 ECE 520 Advanced Device Design and Simulation ..... 3 ECE 530 Digital Hardware Design ..... 3 ECE 550 Stochastic Signals and Systems ..... 3 ECE 560 Linear Systems 3	10
Major Area of Concentration	15
Emphasis (Minor) Area	9
Electives (with supervisory committee approval)	12
Comprehensive Examination ECE 600 Assessment [Ph.D. Comprehensive Examination] (P/F) ..... 1 **Dissertation Proposal** ECE 600 Assessment [Ph.D. Dissertation Proposal] (P/F) ..... 1 **Culminating Activity** ECE 693 Dissertation (P/F) 24	26
TOTAL	72

Areas of Concentration and Emphasis

15 credits of coursework are required in a Major Area of Concentration. This is to be 5xx and 6xx courses beyond the core sequence from one area chosen from the three ECE Areas: Computer Engineering, Circuits and Devices, or Signals and Systems. An additional 9 credits of coursework is required beyond the core sequence in an Emphasis or Minor Area also at the 5xx or 6xx level. This should be in one of the two remaining ECE Areas. The Areas are defined as follows: Computer Engineering (all ECE courses with a middle digit of 3), Circuits and Devices (all ECE courses with a middle digit of 1, 2, 4 or 8), and Signals and Systems (all ECE courses with a middle digit of 5, 6 or 7). Of these 24 credits, 12 must be at the 600-level.

Ph.D. Examinations and Dissertation Requirements

Students admitted to the Ph.D. program will be required to pass a comprehensive exam and an oral dissertation proposal. As a culminating activity, the student will be required to present, and successfully defend, a doctoral research dissertation presenting significant research augmenting existing knowledge in the field of electrical and computer engineering.

Comprehensive Examination

The comprehensive examination is given yearly in January. Generally, students entering the program with a Bachelor's degree take the comprehensive examination after the third semester of study. Students entering with a Master's degree take the written comprehensive examination, generally, the first time it is offered after their admission. This examination will test depth and breadth of knowledge over 3 of the 6 core courses: 500 (electromagnetics), ECE 510 (circuits), 520 (devices), 530 (digital), and 550 (communications), 560 (systems). The results of the comprehensive examination can lead to three possible outcomes: 1) pass, 2) pass after completion of background coursework with grades of A or B to resolve deficiencies (note that this coursework will not count towards the Ph.D. degree credits required for graduation), or 3) failure. If the student fails the comprehensive examination they may take it again the following year. Failure a second time will result in administrative withdrawal from the doctoral program.

Dissertation Proposal

The oral dissertation proposal is designed to assess the suitability of a Ph.D. student for research in a specific area and will focus on advanced coursework and research in the student's dissertation area. Satisfactory completion is required for the student to become a Ph.D. candidate. The dissertation proposal should be presented before, or at the beginning of, the student's Ph.D. research and within one year of satisfactory completion of the comprehensive examination. To initiate the dissertation proposal, the student must submit a research proposal for their doctoral dissertation to their Supervisory Committee. After the Supervisory Committee reviews the proposal they can give their approval to proceed with scheduling the oral presentation or they can ask the student to make changes to the proposal and to resubmit it. The oral dissertation presentation consists of the student presenting their proposed doctoral research and answering questions about the proposal, related background material and the material covered in all courses listed in their program of study. If a student fails the oral presentation, they may be allowed to reinitiate the dissertation proposal once with the approval of the Supervisory Committee. Students who fail a second time or do not receive approval to resubmit the proposal will be administratively withdrawn from the program.

Dissertation Requirements

The dissertation must be the result of independent and original research by the student and must constitute a significant contribution to electrical and computer engineering knowledge equivalent to multiple peer-reviewed publications. The style and format of the dissertation are to conform to the standards of the Department of Electrical and Computer Engineering and the Graduate College.

Final Oral Examination

A public defense of the dissertation is scheduled after the Supervisory Committee has reviewed a draft that is considered to be nearly a final version. The date of the defense is determined jointly by the Supervisory Committee and the student and must be consistent with any guidelines provided by the Graduate College. A Defense Committee is formed that consists of the following voting members: an appointed chair, the chair and members of the Supervisory Committee, and an external examiner. The chair of the Defense Committee is appointed by the Dean of the Graduate College and must be a member of the Graduate Faculty, but must not be the chair or a member of the Supervisory Committee. The external examiner is a faculty member from another university who is a recognized expert in the field of the dissertation research and is appointed to the Defense Committee by the Dean of the Graduate College. Attendance at the defense by the external examiner is not required, but a written evaluation of the dissertation and a pass or fail vote must be submitted by the external examiner to the chair of the Defense Committee at least 3 weeks prior to the defense. The written evaluation provided by the external examiner is distributed to the other members of the Defense Committee at least 2 weeks before the defense. The chair of the Defense Committee conducts the defense according to the procedure established by the Doctoral Program Committee. A student who fails the defense may be permitted to try again, but failure a second time will result in dismissal from the program.

Final Approval of the Dissertation

If the defense is completed with a result of pass, the Supervisory Committee prepares a statement describing final requirements such as additions or modifications to the dissertation and any additional requirements such as archival of data. When these requirements have been met to the satisfaction of the Supervisory Committee, the approval page of the dissertation is signed by the members of the Committee.

Graduate College Requirements

The general requirements of the BSU Graduate College also govern the Doctor of Philosophy in Electrical and Computer Engineering degree program.

Master of Science/Master of Engineering

General Information

The Department of Electrical and Computer Engineering offers four distinct engineering graduate degree programs. Two programs leading to the Master of Science in Computer Engineering (M.S. COMPE) and Master of Science in Electrical Engineering (M.S. EE) are thesis-based programs designed to prepare students for research and development and further study at the doctoral level. The programs leading to the Master of Engineering in Computer Engineering (M.Engr. COMPE) and Master of Engineering in Electrical Engineering (M.Engr. EE) are non-thesis programs with a focus on professional development.

Application and Admission Requirements

Admission Requirements An applicant must satisfy the minimum admission requirements of the Graduate College. In addition, the applicant must hold a baccalaureate degree in computer or electrical engineering from an ABET-accredited program or a baccalaureate degree in a closely related field, and must follow the application procedures specified below. Admission is competitive and the achievement of minimum requirements does not guarantee admission.

Application Procedures A prospective student may apply at any time and should follow the general graduate application procedure for degree-seeking students (see Applying as a Degree-Seeking Student in this catalog). The applicant must also arrange to have GRE General Test scores submitted by the Educational Testing Service (www.ets.org) directly to Boise State University (code R4018). Applicants holding a baccalaureate degree from the College of Engineering of Boise State University are not required to submit GRE scores. International applicants must submit a statement of purpose to the graduate program coordinator and arrange for three letters of recommendation to be submitted directly by the references to the Boise State University International Admissions Office. The statement of purpose should give the educational and professional background of the student and his or her motivation for graduate study including career goals. Once the applicant's file is complete, it will be evaluated by the Graduate Studies Committee and an admission recommendation (regular, provisional, or denial) will be forwarded to the Dean of the Graduate College. In order to ensure proper mentoring of all graduate students, a recommendation for regular or provisional admission will not be forwarded unless a faculty member of the Department of Electrical and Computer Engineering is available to serve as the major advisor. The graduate dean will make the final admission decision and notify the applicant and the Graduate Studies Committee.

Advisor and Supervisory Committee

For a student admitted to the M.S. in Computer Engineering or the M.S. in Electrical Engineering program, the Graduate Studies Committee will initiate the assignment of a supervisory committee including a major advisor who serves as chair. The role of the supervisory committee is to guide the student in all aspects of his or her graduate study. For a student admitted to the M.Engr. in Computer Engineering or the M.Engr. in Electrical Engineering, the Graduate Studies Committee will appoint a major advisor; student mentoring will be provided by the major advisor and the chair of the department.

Special Rule on Transfer Credit The normal transfer credit policies of the Graduate College hold except that up to 15 transfer credits earned in combination at the University of Idaho and Idaho State University may be applied to either degree program (M.S.COMPE, M.S. EE, M.Engr. COMPE, or M.Engr. EE) with the approval of the supervisory committee.

Master of Science in Computer Engineering

Graduate Program Coordinator: Jennifer A. Smith
Micron Engineering Center, Room 202L, Mail Stop 2075
Telephone (208) 426-5743
e-mail: jasmith@boisestate.edu

Degree Requirements

Students must complete at least 30 graduate credits distributed as shown in the degree requirements table. A written thesis proposal with oral presentation to the supervisory committee is required prior to the completion of 15 credits applicable to the degree requirements. Work on the thesis can only be undertaken after approval of the thesis proposal by the supervisory committee. The thesis must constitute an original contribution to knowledge in computer engineering and must be successfully defended at a final oral examination. All work directly related to the thesis must be represented by at least 6 credits of ECE 593.

Master of Science in Computer Engineering	
Course Number and Title	**Credits**
Graduate Courses Related to Computer Engineering Graduate courses in computer engineering; computer science, or electrical engineering; all courses to be selected with student input and approved by the supervisory committee.	15-24
Other Graduate Courses Graduate courses in computer engineering or a related field; all courses to be selected with student input and approved by the supervisory committee.	0-9
Thesis ECE 593 Thesis (P/F)	6
TOTAL	**30**

Master of Engineering in Computer Engineering

Graduate Program Coordinator: Jennifer A. Smith
Micron Engineering Center, Room 202L, Mail Stop 2075
Telephone (208) 426-5743
e-mail: jasmith@boisestate.edu

Degree Requirements

Students must complete at least 31 graduate credits distributed as shown in the degree requirements table. A maximum of 3 credits of ECE 696 Directed Research may be applied to meet the degree requirements. The comprehensive examination cannot be attempted prior to the last semester of the program. If the comprehensive examination is failed on the first attempt, then the student will be permitted a second attempt. Failure on the second attempt will result in dismissal from the program.

Master of Engineering in Computer Engineering	
Course Number and Title	**Credits**
Graduate Courses Related to Computer Engineering Graduate courses in computer engineering, computer science or electrical engineering; all courses to be selected with student input and approved by the supervisory committee.	18-30
Other Graduate Courses Graduate courses in computer engineering or a related field; all courses to be selected with student input and approved by the supervisory committee.	0-12
Comprehensive Examination ECE 600 Assessment (P/F)	1
TOTAL	**31**

Master of Science in Electrical Engineering

Graduate Program Coordinator: Said Ahmed-Zaid
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e-mail: sahmedzaid@boisestate.edu

Degree Requirements

Students must complete at least 30 graduate credits distributed as shown in the degree requirements table. A written thesis proposal with oral presentation to the supervisory committee is required prior to the completion of 15 credits applicable to the degree requirements. Work on the thesis can only be undertaken after approval of the thesis proposal by the supervisory committee. The thesis must constitute an original contribution to knowledge in electrical engineering and must be successfully defended at a final oral examination. All work directly related to the thesis must be represented by at least 6 credits of ECE 593.

Master of Science in Electrical Engineering	
Course Number and Title	**Credits**
Graduate Courses Related to Electrical Engineering Graduate courses in electrical engineering; all courses to be selected with student input and approved by the supervisory committee.	15-24
Other Graduate Courses Graduate courses in electrical engineering or a related field; all courses to be selected with student input and approved by the supervisory committee.	0-9
Thesis ECE 593 Thesis (P/F)	6
TOTAL	**30**

Master of Engineering in Electrical Engineering

Graduate Program Coordinator: Said Ahmed-Zaid
Micron Engineering Center, Room 202H, Mail Stop 2075
Telephone (208) 426-4073
e-mail: sahmedzaid@boisestate.edu

Degree Requirements

Students must complete at least 31 graduate credits distributed as shown in the degree requirements table. A maximum of 3 credits of ECE 696 Directed Research may be applied to meet the degree requirements. The comprehensive examination cannot be attempted prior to the last semester of the program. If the comprehensive examination is failed on the first attempt, then the student will be permitted a second attempt. Failure on the second attempt will result in dismissal from the program.

Master of Engineering in Electrical Engineering	
Course Number and Title	**Credits**
Graduate Courses Related to Electrical Engineering Graduate courses in electrical engineering; all courses to be selected with student input and approved by the supervisory committee.	18-30
Other Graduate Courses Graduate courses in electrical engineering or a related field; all courses to be selected with student input and approved by the supervisory committee.	0-12
Comprehensive Examination ECE 600 Assessment (P/F)	1
TOTAL	**31**

Course Offerings

ECE—ELECTRICAL AND COMPUTER ENGINEERING

ECE 500 APPLIED ELECTROMAGNETICS (3-0-3)(S). An applied study of electromagnetic theory and its applications to wave propagation in bounded structures, scattering and diffraction, antenna theory, S-parameters, and microwave engineering. PREREQ: ECE 390 or PHYS 382.

ECE 501 PLASMA ENGINEERING (3-0-3)(F)(Odd years). An introduction to plasma principles and the use of plasmas in semiconductor processing. The course provides an introduction to the basic concepts of the Debye length, plasma sheaths, and the properties of waves in plasmas. The principles involved in the chemistry and the physical aspects of plasma discharges are covered related to etch, deposition, and ion implantation. PREREQ: MATH 275, MATH 333 or MATH 433, and PHYS 212.

ECE 510 INTEGRATED CIRCUIT PHYSICAL DESIGN (3-0-3)(F/S). CMOS IC layout, modeling, parasitic capacitance extraction, SPICE simulation. Design of logic gates, counters, registers, memories, and photomasks. PREREQ: ECE 322.

ECE 511 CMOS ANALOG IC DESIGN (3-0-3)(F/S). Design, layout, and simulation of CMOS analog integrated circuits. Current mirrors, voltage and current references, amplifiers, and op-amps. PREREQ: ECE 410/510.

ECE 513 RF IC DESIGN (3-0-3)(F/S). Design and characterization of RF-CMOS integrated circuits, including RF transceivers, oscillators, design approaches for handheld wireless systems, ultra-low-power circuit design techniques, on-wafer microwave measurement techniques. S parameter device evaluation methods, low-noise design and measurement, analysis of distortion in amplifiers, power amplifiers with application to wireless transmitter design, transmission lines and distributed circuit elements. PREREQ: ECE 410 or ECE 411.

ECE 518 MEMORY CIRCUIT DESIGN (3-0-3)(F/S)(Alternate years). Transistor level design of memory circuits. Memory technologies including DRAM, Flash, MRAM, Glass-based, and SRAM will be discussed. The course will be a practical introduction to the design of memory circuits. PREREQ: ECE 410/510.

ECE 520 ADVANCED DEVICE DESIGN AND SIMULATION (3-0-3)(F/S). MOSFET device physics, scaling rules, analytical short channel models, hot-electron effects/modeling, LDD design, gate oxide breakdown and reliability, TDDB, GIDL, channel mobility, electromigration, BSIM3 device modeling, 2-D TCAD device simulation. PREREQ: ECE 323.

ECE 520L ADVANCED DEVICE CHARACTERIZATION LAB (0-3-1)(F/S). Advanced measurement and parameter extraction techniques for MOSFETs. High frequency CV, Quasistatic CV, Charge-Pumping measurements, PREREQ: ECE 323.

ECE 521 ADVANCED TOPICS IN SEMICONDUCTOR DEVICES (3-0-3)(F/S). Study of advanced semiconductor devices, particularly photonic, microwave, power, and high temperature/radiation resistant devices, including physics and applications. TCAD simulation and modeling of these devices will be included. PREREQ: ECE 420/520.

ECE 522 MICROWAVE SEMICONDUCTOR DEVICES (3-0-3)(F/S). Covers the various aspects of design, fabrication, and characterization of ultra-low-power, RF-CMOS devices. Short-channel CMOS device physics, Parasitic CMOS device elements, Advanced small-signal bulk and SOI RF-CMOS device models, Ultra-low-power device and circuit design techniques, On-wafer microwave measurement and calibration techniques, and S-parameter device evaluation methods. PREREQ: ECE 420/520.

ECE 530 DIGITAL HARDWARE DESIGN (3-0-3)(F/S). Advanced topics in digital system design emphasizing the specification and design of complex digital hardware systems. Applications include design of synchronous state machines, asynchronous digital systems, and simple digital control circuits using hardware descriptive languages for field programmable gate arrays and complex programmable logic. PREREQ: ECE 230 and either COMPSCI 117 or COMPSCI 125.

ECE 532 COMPUTER ARCHITECTURE (3-0-3)(F/S). Structure of computer systems using processors, memories, input/output (I/O) devices as building blocks. Computer system instruction set design and implementation, including memory hierarchies, microprogramming, pipelining, and multiprocessors. Issues and tradeoffs and multi-variable optimization algorithms using linear and nonlinear programming methods to design problems in structures, machine components, and energy systems. PREREQ: ECE 332 and COMPSCI 117 or COMPSCI 125.

ECE 533 EMBEDDED AND PORTABLE COMPUTING SYSTEMS (3-0-3)(F/S). Comparison of commercially available microcontrollers and their use in embedded communications and control applications. Power consumption, software development, interprocessor communication, and interfacing with sensors, actuators, and input/output devices. Use of microcontroller cores implemented in programmable logic devices as an alternative to hardwired microcontrollers. An embedded system project is designed and built. PREREQ: ECE 332.

ECE 534 COMPUTER NETWORKS (3-0-3)(F/S). Concepts of computer networks and architectures. Network topology, connectivity analysis, delay analysis, local access design. Physical layer, data link layer, higher layer protocols. Study of networks as distributed embedded systems. Routing, flow control, congestion control. Local area networks. PREREQ: ECE 332.

ECE 535 SYSTEMS FOR MULTIMEDIA PROCESSING (3-0-3)(F/S). Study of the general information theory and its applications in speech, imaging, and video processing. Focuses on the underlying structures and architectures for efficient algorithm implementation of video and speech processing systems. Current and future trends in processing, storing, coding, decoding, restoring, and transmission of multimedia information. PREREQ: ECE 457/557 and ECE 430/530, or PERM/INST.

ECE 536 DIGITAL SYSTEMS RAPID PROTOTYPING (3-0-3)(F/S). Use of hardware description languages and hardware programming languages as a practical means to simulate/implement hybrid sequential and combinational systems. Rapid prototyping techniques will be utilized during the implementation. This course focuses upon the actual design and implementation of sizeable digital design problems using the most up-to-date industry Computer Aided Design tools and Field-programmable Gate Arrays. PREREQ: ECE 430/530.

ECE 537 ASIC CHIP DESIGN (3-0-3)(F/S). Study of phases of ASIC development implementing standard, specialized and DSP applications. Course covers specifications and pre-design analysis mapping design units into architectures, evaluation of early design choices using CAD behavioral synthesis tools and design libraries, simulation, functional and timing verification issues, synthesis, design optimization, testing, and evaluation. The course supports individual and group projects to build ASICs implementing RISCs/DSPs/Superscalars/Fuzzy Logic based systems using standard ASIC design CAD tools. PREREQ: ECE 430/530 and ECE 432/532.

ECE 540 INTRO TO INTEGRATED CIRCUIT AND MEMS PROCESSING (3-0-3)(F). Fundamentals of integrated circuit and micro electromechanical systems (MEMS) fabrication technology; semiconductor substrates; theory of unit processes such as diffusion, oxidation, ion implantation, rapid thermal processing, photolithography, wet etching and cleaning, dry etching, thin-film deposition; chemical mechanical polishing; process integration; metrology; statistical process control; TCAD. COREQ: ECE 540L. PREREQ: ECE 323 or PERM/INST.

ECE 540L INTRO TO INTEGRATED CIRCUIT AND MEMS PROCESSING LAB (0-3-1)(F). Semiconductor cleanroom practices; heavy lab safety; students will fabricate and test simple structures in lab; application of TCAD to practical problems. COREQ: ECE 540.

ECE 541 ADVANCED TOPICS IN SILICON TECHNOLOGY (3-0-3)(S). Advanced models for unit processes such as diffusion, oxidation, ion implantation, thin film deposition, etching, rapid thermal processing, chemical mechanical polishing, lithography. CMOS, bipolar, and micro electro mechanical systems (MEMS) process integration. Process and device modeling using TCAD. PREREQ: ECE 440/540.

ECE 542 PHOTOLITHOGRAPHY (3-0-3)(F/S). Principles of optics, diffraction, interference, superposition of waves, imaging systems, fundamentals of microlithography, resolution, contact and projection lithography, photoresist processing, metrology. Phase shift masks, anti-reflective coatings, deep-ultraviolet lithography, off-axis annular illumination. Use of TCAD lithography simulation software. COREQ: ECE 442.

ECE 542L PHOTOLITHOGRAPHY LAB (0-3-1)(F/S). Cleanroom lab experience accompany ECE 542, utilizing a projection-printing wafer stepper, photoresist wafer track, SEM, and optical metrology equipment. Use of TCAD lithography simulation software. PREREQ: ECE 342. COREQ: ECE 542.

ECE 543 INTRODUCTION TO MEMS (3-0-3)(F/S). Overview of MEMS; MEMS device physics including beam theory, electrostatic actuation, capacitive and piezoresistive sensing, thermal sensors and actuators; basic MEMS fabrication techniques; MEMS technologies: bulk micromachining, surface micromachining, and LIGA; MEMS design and modeling; case studies in various MEMS systems. PREREQ: ECE 440/540, or PERM/INST.

ECE 550 STOCHASTIC SIGNALS AND SYSTEMS (3-0-3)(S). Deterministic signal representations and analysis, introduction to random processes and spectral analysis, correlation function and power spectral density of stationary processes, noise mechanisms, the Gaussian and Poisson processes. Markov processes, the analysis of linear and nonlinear systems with random inputs, stochastic signal representations, orthogonal expansions, the Karhunen-Loeve series, channel characterization, introduction to signal detection, linear mean-square filtering, the orthogonality principle, optimum Wiener and Kalmen filtering, modulation theory, and system analysis. PREREQ: ECE 350 and MATH 360 or MATH 361 or equivalent.

ECE 551 COMMUNICATION SYSTEMS (3-0-3)(F). Signals, noise, propagation and protocol in analog and digital communication systems. Bandwidth, Fourier transforms, signal to noise ratio and receiver noise figures. Introduction to modern wireless communication systems such as cellular, wireless data and satellite data systems. PREREQ: ECE 350, and MATH 360 or MATH 361, or PERM/INST.

ECE 552 WIRELESS COMMUNICATIONS (3-0-3)(F/S). Modern cellular communication systems, including propagation, handoff, noise, and interference studies. CDMA and other spread-spectrum systems. PREREQ: ECE 451 or ECE 551.

ECE 554 DIGITAL SIGNAL PROCESSING (3-0-3)(F/S). Modern digital signal processing in engineering systems. Review of continuous-time and discrete-time signals, spectral analysis; design of FIR and IIR digital filters. Fast Fourier Transform, two-dimensional signals, realization structure of digital filters, and filter design. PREREQ: ECE 350.

ECE 556 PATTERN RECOGNITION (3-0-3)(S)(Alternate years). Basic concepts of statistical and neural pattern recognition. Structure of pattern classification problems. Mathematics of statistical decision theory; multivariate probability functions, discriminant, parametric and nonparametric techniques. Bayesian and maximum likelihood estimation, feature selection, dimensionality reduction, neural network recognition and clustering. PREREQ: COMPSCI 225, and either MATH 360 or MATH 361.

ECE 557 DIGITAL IMAGE PROCESSING (3-0-3)(F). Pictures and their computer representation. Image digitization, transformation, and prediction methods. Digital enhancement techniques, histogram equalization, restoration, filtering and edge detection. Color models and transformations. Wavelets and morphological algorithms. PREREQ: ECE 350 and COMPSCI 125, or PERM/INST.

ECE 560 LINEAR SYSTEMS (3-0-3)(F/S). Methods of analysis for continuous and discrete-time linear systems. Classical solution of dynamic equations, transforms and matrices are reviewed. Emphasis is on the concept of state space. Linear spaces, concept of state, modes, controllability, observability, canonical forms, state transition matrices and irreducible realizations. State variable feedback, compensation and decoupling. PREREQ: ECE 360, ME 360 or graduate standing.

ECE 561 (ME 561) CONTROL SYSTEMS (3-0-3)(S). Time and frequency domain analysis and design of feedback systems using classical and state space methods. Observability, controllability, pole placement, observers, and discrete time. Multivariable and optimal methods are introduced. May be taken for ECE or ME credit, but not both. PREREQ: ECE 360 or ME 360.

ECE 564 ROBOTICS AND AUTOMATED SYSTEMS (3-0-3)(F/S). An introduction to robotics with emphasis on automated systems applications. Topics include: basis components of robotic systems; selection of coordinate frames; homogeneous transformations; solutions to kinematic equations; velocity and force/torque relations; manipulator dynamics; digital simulation of manipulator motion; motion planning; actuators of robots; sensors of robots; obstacle avoidance; and control design. PREREQ: ECE 360, ME 360 or PERM/INST.

ECE 570 ELECTRIC MACHINES (3-0-3)(S). Magnetic materials and magnetic circuits, Transformers. Principles of electromechanical energy conversion, energy and coenergy concepts, forces and torques of electromagnetic origin. Introduction to rotating machines including synchronous machines and induction machines. PREREQ: ECE 225 and ECE 390.

ECE 571 ELECTRIC MOTOR DRIVES (3-0-3)(F)(Even years). Induction machines and drives, direct-current and permanent-magnet machines and drives, synchronous machines and drives. Control of single-phase and special machines. PREREQ: ECE 360 or ME 360 and ECE 470/570, or PERM/INST.

ECE 572 POWER ELECTRONICS (3-0-3)(F). Power electronic switches, diode and controlled rectifiers, AC-AC phase control, DC-DC converters, inverters, introduction to electric drives and power quality fundamentals. PREREQ: ECE 225.

ECE 573 POWER SYSTEM ANALYSIS I (3-0-3)(F). Three-phase AC systems, generators, transformers, transmission lines, one-line diagrams, per-unit system, network calculations, load flow studies, power system operation. PREREQ: ECE 225, ECE 390.

ECE 574 POWER SYSTEM ANALYSIS II (3-0-3)(S). Fault analysis, symmetrical components, power system transients, protection and relaying,

transient stability, power system operation and control, power system economics, power quality, and power system reliability. PREREQ: ECE 473/573.

ECE 601 ADVANCED ELECTROMAGNETIC THEORY (3-0-3)(S)(Even years). Advanced topics in static and dynamic electromagnetic field theory for engineering applications including bounded structures and radiators; solution of scalar and vector boundary value problems; Kirchhoff radiation theory; geometrical diffraction theory, and numerical methods. PREREQ: ECE 500.

ECE 602 PLASMA AND ELECTRON DEVICES (3-0-3)(F)(Even years). Advanced topics in plasma devices including plasma waves, plasma generation, and device applications for plasma processing and vacuum electronics. Advanced topics in microwave vacuum electron devices including oscillators and amplifiers for both high power and high frequency. PREREQ: ECE 500 and ECE 501.

ECE 614 ADVANCED ANALOG IC DESIGN (3-0-3)(F/S). Advanced analog design considerations including: noise, common-mode feedback, high-speed, design for signal processing, filter design. PREREQ: ECE 411/511.

ECE 615 CMOS MIXED-SIGNAL IC DESIGN (3-0-3)(F/S). Design of Nyquist-rate A/D and D/A converters, sigma-delta data converters, and custom digital filters. PREREQ: ECE 411/511.

ECE 629 QUANTUM EFFECTS IN MOS DEVICES (3-0-3)(F/S). Computational methods will be used to examine quantum mechanical effects in MOS devices. Effects such as tunneling, triangular quantum well effects and poly-Si depletion will be examined. PREREQ: ECE 323 and PHYS 310.

ECE 631 DIGITAL SYSTEM TESTING AND TESTABLE DESIGN (3-0-3)(F/S). In-depth theory and practice of fault analysis, test set generation, and design for testability of digital systems. Topics include system modeling; fault sources and types; fault simulation methods; automatic test pattern generation (ATPG) for combinatorial and sequential circuits; testability measures; design-for-testability; scan design; test compression methods; logic-level diagnosis; built-in self-testing (BIST); VLSI testing issues; processor and memory testing. Advance research issues, including topics on mixed signal testing are also discussed. PREREQ: ECE 430/530, and ECE 410/510.

ECE 632 ADVANCED COMPUTER ARCHITECTURE (3-0-3)(F/S). Study of up-to-date multiprocessor systems and parallel computing architectures. Covers basic architectural concepts and their performance evaluation, design principles of VLIW and superscalar architectures, multithread and data-flow computers, shared and distributed memory MIMDS, associative and neural architectures. Focuses on significant trends in building systems on a chip. PREREQ: ECE 432/532.

ECE 634 LARGE SCALE DISTRIBUTED SYSTEMS DESIGN (3-0-3)(F/S). Fundamental principles, critical issues and latest techniques involved in the design of advanced computer controlled systems. Emphasizes using design requirements, hardware-software tradeoffs, redundancy, and testability to develop highly reliable systems. Topics include software-hardware tradeoffs, memory hierarchy design, calculation of availability, simulation, and communication requirements. Tools and techniques used to develop systems. Incorporates case studies of actual systems. A design project will be included and consists of designing a system driven by embedded computers. PREREQ: ECE 432/532.

ECE 635 HARDWARE IMPLEMENTATION OF DSP ALGORITHMS (3-0-3)(F/S). Implementation methods of DSP algorithms in programmable logic environment. Hardware required for DSP implementation: architectures; arithmetic; digital filters including FIR, IIR and CIC. Course will also cover the efficient implementation of these algorithms and their impact on the implementation process and product costs. PREREQ: ECE 454/554 and ECE 430/530.

ECE 636 HARDWARE/SOFTWARE CODESIGN (3-0-3)(F/S). Covers system level design of embedded systems with a top-down design approach. The students will learn various design steps starting from system specifications to hardware/software implementation and will experience process optimization while considering various design decisions. Students will gain design experience with project/case studies using contemporary high-level methods and tools. PREREQ: ECE 436/536.

ECE 637 SYSTEM ON A PROGRAMMABLE CHIP (3-0-3)(F/S). Covers the design of embedded system within a single integrated circuit. Such a system consists of multiple intellectual property cores interconnected by common infrastructure. This course will also explore the challenges to design and test a complete system on chip. Exercises/projects will be given to design, synthesize, and simulate using modern computer aided design (CAD) tools. Resulting systems will be targeted in reprogrammable hardware. PREREQ: ECE 436/536.

ECE 640 ADVANCED MICROFABRICATION (3-0-3)(F/S). Advanced micro/nano-fabrication techniques; advanced process modeling and simulation of thermal processes, ion implantation, thin-film deposition, dry etching, CMP, and lithography; CMOS/device integration; process variability and control; metrology; parametric test. PREREQ: ECE 440/540.

ECE 646 FRONTIERS OF IC PROCESSING (3-0-3)(F/S). Recent and proposed developments in semiconductor process technology Course modules: Lithography, Deposition, Doping and Etch processes. PREREQ: ECE 440/540.

ECE 651 INFORMATION AND CODING THEORY (3-0-3)(F/S). Information measures, characterization of information sources, coding for discrete sources, the noiseless coding theorems, construction of Huffman codes. Discrete channel characterization, channel capacity, noisy-channel coding theorems, reliability exponents. Various error-control coding and decoding techniques, including block and convolutional codes. Introduction to waveform channels and rate distortion theory. PREREQ: ECE 550.

ECE 652 ADVANCED COMMUNICATIONS THEORY (3-0-3)(F/S). Principles of modern communication systems. Elements of information theory, source encoding, efficient signaling with coded waveforms, convolutional codes; carrier recovery and synchronization under AGN channel; adaptive equalization; maximum likelihood estimation, Viterbi algorithm. PREREQ: ECE 450/550.

ECE 657 ADVANCED DIGITAL IMAGE PROCESSING (3-0-3)(F/S). Advanced course in digital image processing. Topics will include image storage formats, image compression techniques, acquisition system calibration, geometric transformations, edge detection and image segmentation, adaptive techniques, video, halftoning, 3D images and topics of specific student interest. PREREQ: ECE 557 or equivalent.

ECE 661 NONLINEAR SYSTEMS (3-0-3)(F/S). Phenomena peculiar to nonlinear systems. Linearization, iteration and perturbation procedures. Describing function stability analysis. Phase plane methods. Relaxation oscillations and limit cycles. Stability analysis by Lyapunov's method. Popov's theorem. Adaptive control systems. Sensitivity analysis. PREREQ: ECE 560.

ECE 666 MULTIVARIABLE CONTROL SYSTEMS (3-0-3)(S). Linearization of state variable models. Time response of linear time invariant systems. Controllability, observability, and stability of linear systems. Pole placement by state and output feedback. Observers. Linear quadratic regulator control. PREREQ: ECE 560.

ECE 670 POWER SYSTEM DYNAMICS (3-0-3)(F/S). Dynamic modeling of major power system components and their controls for short-term simulation and stability evaluation of multimachine power systems. Subsynchronous resonance, transient and steady-state stability analysis. Stabilization of electromechanical oscillations via excitation control. Methods of coherency identification and dynamic equivalencing. Voltage stability and control. PREREQ: ECE 470/570 and ECE 473/573.

ECE 681 MMIC DESIGN (3-0-3)(F/S). Technology, design and analysis of monolithic microwave integrated circuits; passive and active microwave circuit elements; high frequency substrates, individual design projects utilize modern computer-aided design software. PREREQ: ECE 500.

ECE 682 QUANTUM ELECTRONICS (3-0-3)(F/S). Quantized electromagnetic field, interaction of radiation and atomic systems, laser oscillation, semiconductor lasers, parametric amplification, phase conjugate optics. PREREQ: PHYS 412/512.