Electrical and Computer Engineering Courses

Many of the ECE courses are restricted to ECE majors only. Please check the quarterly Schedule of Classes. Instructor and quarter offered are subject to change.

LOWER DIVISION

1. Ten Puzzling Problems in Computer Engineering
(1) PARHAMI

Prerequisite: open to pre-computer engineering only. Seminar, 1 hour.

Gaining familiarity with, and motivation to study, the field of computer engineering, through puzzle-like problems that represent a range of challenges facing computer engineers in their daily problem-solving efforts and at the frontiers of research.

2A. Circuits, Devices, and Systems
(5) YORK

Prerequisites: Mathematics 3A-B-C with a minimum grade of C; and, Mathematics 5A with a minimum grade of C (may be taken concurrently); Physics 3 or 23 (may be taken concurrently); open to electrical engineering, computer engineering, and pre-computer engineering majors only. Lecture, 3 hours; laboratory, 4 hours.

Introduction to basic circuit analysis. KCL, KVL, nodal analysis, superposition, independent and dependent sources; diodes and I-V characteristics; basic op-amp circuits; first-order transient analysis; AC analysis and phasors. Introduction to the use of test instruments.

2B. Circuits, Devices, and Systems
(5) YORK

Prerequisites: ECE 2A with a grade of C- or better; open to electrical engineering, computer engineering, and pre-computer engineering majors only. Lecture, 3 hours; laboratory, 4 hours.

Second order circuits. Laplace transform and solution of steady state and transient circuit problems in the s-domain; Bode plots; Fourier series and transforms; filters. Transistor as a switch; load lines; simple logic gates; latches and flip-flops.

2C. Circuits, Devices, and Systems
(5) YORK

Prerequisites: ECE 2B with a grade of C- or better (may be taken concurrently); open to electrical engineering, computer engineering, and pre-computer engineering majors only. Lecture, 3 hours; laboratory, 4 hours.

Two-port network parameters; small-signal models of nonlinear devices; transistor amplifier circuits; frequency response of amplifiers; non-ideal op-amps; modulation, bandwidth, signals; Fourier analysis.

4. Design Project for Freshmen
(4) STAFF

Prerequisites: Mathematics 3A-B-C and Physics 1 with minimum grades of C; Engineering 3 with a minimum grade of C-. Lecture, 3 hours; laboratory, 3 hours.

This first course on design gives an intuitive introduction to engineering design. Learn how to take an idea of a system and convert it to a working model. Use hardware and software for building a system.

15A. Fundamentals of Logic Design
(3) MAREK-SADOWSKA

Prerequisites: ECE 2A with a minimum grade of C-; open to electrical engineering, computer engineering, and pre-computer engineering majors only.

Not open for credit to students who have completed ECE 15. Lecture, 3 hours; discussion, 1 hour.

Boolean algebra, logic of propositions, minterm and maxterm expansions, Karnaugh maps, Quine-McCluskey methods, melti-level circuits, combinational circuit design and simulation, multiplexers, decoders, programmable logic devices.

15B. Computer Organization
(3) STAFF

Prerequisites: ECE 15A with a minimum grade of C-; open to electrical engineering, computer engineering, and pre-computer engineering majors only.

Not open for credit to students who have completed Computer Science 30 or ECE 15. Lecture, 3 hours; discussion, 1 hour.

Basic memory and processor organization, instruction set architecture, assembly language programming, number systems, arithmetic, data transfer and control flow instructions, procedures, memory management, program execution.

94AA-ZZ. Group Studies in Electrical and Computer Engineering
(1-4) STAFF

Prerequisite: consent of instructor.

Group studies intended for small number of advanced students who share an interest in a topic not included in the regular departmental curriculum.

UPPER DIVISION

121A-B. The Practice of Science
(3-4) HU, AWSCHALOM

Prerequisites: consent of instructor (for 121A): ECE 121A or Physics 121A; consent of instructor (for 121B).

Same course as Physics 121A-B. Lecture, 3 hours (for 121A): Lecture, 4 hours (for 121B).

Provides experience in pursuing careers within science and engineering through discussions with researchers, lectures on ethics, funding, intellectual property, and commercial innovation. Students prepare a focused research proposal that is pursued in the second quarter of the course.

124A. VLSI Principles
(4) BANERJEE

Prerequisites: ECE 132 (may be taken concurrently) and ECE 152A with a minimum grade of C- in both. Lecture, 3 hours; laboratory, 3 hours.

Introduction to CMOS digital VLSI design: CMOS devices and manufacturing technology; transistor level design of static and dynamic logic gates and components and interconnections; circuit characterization: delay, noise margins, and power dissipation; combinational and sequential circuits; arithmetic operations and memories.

124B. Integrated Circuit Design and Fabrication
(4) BOWERS

Prerequisite: ECE 132 with a minimum grade of C-. Lecture, 4 hours; laboratory, 3 hours.

Theory, fabrication, and characterization of solid state devices including P-N junctions, capacitors, bipolar and MOS devices. Devices are fabricated using modern VLSI processing techniques including lithography, oxidation, diffusion, and evaporation. Physics and performance of processing steps are discussed and analyzed.

124C. Integrated Circuit Design and Fabrication
(4) BOWERS

Prerequisites: ECE 124B and ECE 137A with a minimum grade of C- in all. Lecture, 4 hours; laboratory, 3 hours.

Design, simulation, fabrication, and characterization of NMOS integrated circuits. Circuit design and layout is performed using commercial layout software. Circuits are fabricated using modern VLSI processing techniques. Circuit and discrete device electrical performance are analyzed.

124D. VLSI Architecture and Design
(4) BREWER

Prerequisite: ECE 124A with a minimum grade of C-.

Lecture, 3 hours; laboratory, 2 hours.

Practical issues in VLSI circuit design, pad/pin limitations, clocking and interfacing standards, electrical packaging for high-speed and high-performance design. On-chip noise and crosstalk, clock and power distribution, architectural and circuit design constraints, interconnection limits and transmission line effects.

125. High Speed Digital Integrated Circuit Design
(4) BANERJEE

Prerequisite: ECE 124A or 137A with a minimum grade of C- in either. Lecture, 4 hours.

Advanced digital VLSI design: CMOS scaling, nanoscale issues including variability, thermal management, interconnects, reliability; non-clocked, clocked and self-timed logic gates; clocked storage elements; high-speed components, PLLs and DLLs; clock and power distribution; memory systems; signaling and I/O design; low-power design.

130A. Signal Analysis and Processing
(4) MADHOW

Prerequisites: Mathematics 5A and ECE 2B with a minimum grade of C- in both; open to EE and computer engineering majors only. Lecture, 3 hours; discussion, 2 hours.

Analysis of continuous time linear systems in the time and frequency domains. Superposition and convolution. Bilateral and unilateral Laplace transforms. Fourier series and Fourier transforms. Filtering, modulation, and feedback.

130B. Signal Analysis and Processing
(4) CHANDRASEKARAN

Prerequisite: ECE 130A with a grade of C- or better; open to EE and computer engineering majors only. Lecture, 3 hours; discussion, 2 hours.

Analysis of discrete time linear systems in the time and frequency domains. Z transforms, Discrete Fourier transforms. Sampling and aliasing.

130C. Signal Analysis and Processing
(4) CHANDRASEKARAN

Prerequisites: ECE 130A-B with a minimum grade of C- in both. Lecture, 3 hours; discussion, 2 hours.

Basic techniques for the analysis of linear models in electrical engineering: Gaussian elimination, vector spaces and linear equations, orthogonality, determinants, eigenvalues and eigenvectors, systems of linear differential equations, positive definite matrices, singular value decomposition.

132. Introduction to Solid State Electronic Devices
(4) MISHRA

Prerequisites: Physics 4 or 24 with a minimum grade of C-; Mathematics 5A with a minimum grade of C; and ECE 2A-B (may be taken concurrently) with a minimum grade of C- in both; open to EE and computer engineering majors only. Lecture, 3 hours; discussion, 2 hours.

Electrons and holes in semiconductors; doping (P and N); state occupation statistics, transport properties of electrons and holes; P-N junction diodes; I-V, C-V, and switching properties of P-N junctions; introduction of bipolar transitors, MOSFET's and JFET's.

134. Introduction to Fields and Waves
(4) DAGLI, YORK

Prerequisites: Physics 3 or 23 with a minimum grade of C-; and Mathematics 5A-B with a minimum grade of C; and Mathematics 5C with a minimum grade of C-; open to EE and computer engineering majors only. Lecture, 3 hours; discussion, 2 hours.

Introduction to applied electromagnetics and wave phenomena in high frequency electron circuits and systems. Wave on transmission-lines, elements of electrostatics and magnetostatics and appications, plane waves, examples and applications to RF, microwave, and optical systems.

135. Optical Fiber Communication
(4) DAGLI

Prerequisites: ECE 132 and 134 with a minimum grade of C- in both. Lecture, 3 hours; discussion, 1 hour.

Optical fiber as a transmission medium, dispersion and nonlinear effects in fiber transmission, fiber and semiconductor optical amplifiers and lasers, optical modulators, photo detectors, optical receivers, wavelength division multiplexing components, optical filters, basic transmission system analysis and design.

137A. Circuits and Electronics I
(4) RODWELL

Prerequisites: ECE 2A-B-C, 130A, and 132 with a minimum grade of C- in all; open to EE majors only. Lecture, 3 hours; laboratory, 3 hours.

Analysis and design of single stage and multistage transistor circuits including biasing, gain, impedances and maximum signal levels.

137B. Circuits and Electronics II
(4) RODWELL

Prerequisites: ECE 2C and 137A with a minimum grade of C- in both; open to EE majors only. Lecture, 3 hours; laboratory, 3 hours.

Analysis and design of single stage and multistage transistor circuits at low and high frequencies. Transient response. Analysis and design of feedback circuits. Stability criteria.

139. Probability and Statistics
(4) ILTIS

Prerequisite: Open to Electrical Engineering, Computer Engineering and pre-Computer Engineering majors only. Lecture, 3 hours; discussion, 2 hours.

Fundamentals of probability, conditional probability, Bayes rule, random variables, functions of random variables, expectation and high-order moments, Markov chains, hypothesis testing.

140. Random Processes for Engineering
(4) ILTIS

Prerequisites: ECE 130A-B and 139 each with a minimum grade of C-; open to EE majors only. Lecture, 3 hours; discussion, 2 hours.

Random processes, characteristic functions, central limit theorem, spectral analysis, linear systems with random inputs, representation of bandlimited processes, Poisson process, simple queueing systems.

141A. Introduction To Nanoelectro-mechanical and Microelectromechanical Systems(NEMS/MEMS)
(3) PENNATUR, TURNER

Prerequisites: ME 16 & 17, ME 152A, ME 151A (may be concurrent); or, ECE 130A and 137A with a minimum grade of C- in both.

Same course as ME 141A. Lecture, 3 hours.

Introduction to nano- and microtechnology. Scaling laws and nanoscale physics are stressed. Individual subjects at the nanoscale including materials, mechanics, photonics, electronics, and fluidics will be described, with an emphasis on differences of behavior at the nanoscale and real-world examples.

141B. Semiconductor Processing and Device Characterization with Laboratory
(4) PENNATUR

Prerequisites: ME 141A or ECE 141A; and, Chemistry 1B-BL.

Same course as ME 141B. Lecture, 2 hours; laboratory, 6 hours.

Lectures and laboratory on semiconductor processing for MEMS. Description and analysis for key semiconductors and equipment used for MEMS. Design and fabrication of MEMS capacitor-actuator and accelerometers; includes a description of MEMS characterization tools.

141C. Introduction to Microfluidics and BioMEMS
(3) MEINHART

Prerequisite: ME 141A or ECE 141A; open to ME and EE majors only.

Same course as ME 141C. Lecture, 3 hours.

Introduces physical phenomena associated with microsale/nanoscale fluid mechanics, microfluids, and bioMEMS. Analytical methods and numerical simulation tools are used for analysis of microfluids.

144. Electromagnetic Fields and Waves
(4) YORK

Prerequisite: ECE 134 with a minimum grade of C-. Lecture, 3 hours; laboratory, 3 hours.

Waves on transmission lines, Maxwell's equations, skin effect, propagation and reflection of electromagnetic waves, microwave integrated circuit principles, metal and dielectric waveguides, resonant cavities, antennas. Microwave and optical device examples and experience with modern microwave and CAD software.

145A. Communication Electronics
(5) LONG

Prerequisites: ECE 137A-B with a minimum grade of C- in both. Lecture, 3 hours; laboratory, 6 hours.

Analog communication circuits 1 MHz to 1GHz with emphasis on receivers. S-parameter design techniques, nonideal components, distortion, amplifier design and characterization, system level analysis.

145B. Communication Electronics
(5) LONG

Prerequisite: ECE 145A with a minimum grade of C-; EE majors only. Lecture, 3 hours; laboratory, 6 hours.

Analog communication circuits 1 MHz to 1GHz with emphasis on receivers. Design and evaluation of RF components: mixers, oscillators, PLL, IF amplifier, FM demodulator, frequency synthesis.

145C. High Speed Bipolar Mixed Signal and Communication IC Design
(4) RODWELL

Prerequisites: ECE 137A-B with a minimum grade of C- in both. Lecture, 4 hours.

Transistor and passive component models. Broadband amplifiers. Fast digital IC design. Circuit noise, digital communication receiver sensitivity. Latched comparator design. Nyquist and oversampled analog-digital and digital-analog converters. Direct digital frequency synthesis. Fiber optic and microwave digital transceivers.

146A. Analog Communication Theory and Techniques
(5) ILTIS

Prerequisites: ECE 130A-B and 140 with a minimum grade of C- in all; open to EE majors only. Lecture, 3 hours; laboratory, 6 hours.

Modulation theory, AM, FM, PM, and analog pulse modulation and demodulation techniques. System noise and performance calculations.

146B. Digital Communication Theory and Techniques
(5) SHYNK

Prerequisites: ECE 130A-B, 140 and 146A with minimum grades of C-; open to EE majors only. Lecture, 3 hours; laboratory, 6 hours.

Elements of source coding: quantization, pulse code modulation, delta modulation. Introduction to digital modulation over baseband and passband channels: linear modulation, Nyquist criterion for intersymbol interference avoidance, orthogonal modulation. Optimal reception of signals in Additive White Gaussian Noise: detection theory basics, signal space concepts, geometry of maximum likelihood receivers. Performance analysis of optimal receivers: error probability as a function of Eb/N0, union bound, nearest neighbors approximation. Link design: power-bandwidth tradeoffs, link budget analysis.

147A. Feedback Control Systems - Theory and Design
(5) TEEL, SMITH

Prerequisites: ECE 130A-B-C with a minimum grade of C- in each; open to EE and computer engineering majors only. Lecture, 3 hours; laboratory, 6 hours.

Feedback systems design, specifications in time and frequency domains. Analysis and synthesis of closed loop systems. Computer aided analysis and design.

147B. Digital Control Systems - Theory and Design
(5) SMITH, TEEL

Prerequisite: ECE 147A with a minimum grade of C-; open to EE and computer engineering majors only. Lecture, 3 hours; laboratory, 6 hours.

Analysis of sampled data feedback systems; state space description of linear systems; observability, controllability, pole assignment, state feedback, observers. Design of digital control systems. (W)

147C. Control System Design Project
(5) HESPANHA

Prerequisite: ECE 147A or ME 155B or ME 173 with a minimum grade of C-. Lecture, 3 hours; laboratory, 6 hours.

Students are required to design, implement, and document a significant control systems project. The project is implemented in hardware or in high-fidelity numerical simulators. Lectures and laboratories cover special topics related to the practical implementation

of control systems.

148. Applications of Signal Analysis and Processing
(4) LEE

Prerequisites: ECE 130A-B with a minimum grade of C- in both. Lecture, 3 hours; discussion, 2 hours.

A sequence of engineering applications of signal analysis and processing techniques; in communications, image processing, analog and digital filer design, signal detection and parameter estimation, holography and tomography, Fourier optics, and microwave and acoustic sensing.

149. Active and Passive Network Synthesis
(4) ILTIS

Prerequisite: Upper-division standing; open to EE majors only.

Designed for juniors to take right after ECE 130AB.

Combines the areas of electronics and network theory in the subject of passive and active network design. Topics include passive synthesis, optimization techniques, approximations to ideal filters, distributed networks, sensitivity and the modern design techniques, and applications of active filters.

151. Distributed Systems
(4) MELLIAR-SMITH

Prerequisite: Computer Science 170 with a minimum grade of C-.

Not open for credit to students who have completed Computer Science 171. Lecture, 3 hours; discussion, 1 hour.

Distributed systems architecture, distributed programming techniques, message passing, remote procedure calls, group communication and membership, naming, asynchrony, causality, consistency, fault-tolerance and recovery, resource management, scheduling, monitoring, testing and debugging.

152A. Digital Design Principles
(5) RODOPLU

Prerequisites: ECE 15 or 15A or Computer Science 30 with a minimum grade of C- in each course; open to electrical engineering, computer engineering, and computer science majors only. Lecture, 3 hours; laboratory, 6 hours.

Design of synchronous digital systems: timing diagrams, propagation delay, latches and flip-flops, shift registers and counters, Mealy/Moore finite state machines, Verilog, 2-phase clocking, timing analysis, CMOS implementation, S-RAM, RAM-based designs, ASM charts, state minimization.

152B. Digital Design Methodologies
(5) CHENG

Prerequisites: ECE 152A with a minimum grade of C-; open to EE, computer engineering, and computer science majors only. Lecture, 3 hours; discussion, 6 hours.

Design methodologies of digital systems, the register and processor levels. Design of functional subsystems, including arithmetic processors, hardwired and microprogrammed control units, memory systems, and bussing systems. System organization including communication, input/output systems, and multiple CPU systems.

153A. Hardware/Software Interface
(4) STAFF

Prerequisite: Computer Science 130A with a minimum grade of C-.

Same course as Computer Science 153A.

The study of the structures employed at the interface of hardware and software in modern computing systems. Instruction set architecture (ISA) design trade-offs, operating system and hardware support for input/output devices (memory-mapping, interrupts, device drivers). Operating system and real-time system scheduling of tasks. Low level software and program support infrastructures (virtualization, compilation, optimization, emulation/simulation, debugging).

153B. Sensor and Peripheral Interface Design
(4) BUTNER

Prerequisites: ECE 152B and 153A with a minimum grade of C- in both. Lecture, 3 hours; laboratory, 3 hours.

Hardware description languages; field-programmable logic and ASIC design techniques. Mixed-signal techniques: A/D and D/A converter interfaces; video and audio signal acquisition, processing and generation, communication and network interfaces.

154. Introduction to Computer Architecture
(4) PARHAMI

Prerequisite: ECE 152A with a minimum grade of C-; open to EE, computer engineering, and computer science majors only.

Not open for credit to students who have completed Computer Science 154. Lecture, 3 hours; discussion, 1 hour.

The computer design space. Methods of performance evaluation. Machine instructions and assembly language. Variations in instruction set architecture. Design of arithmetic/logic units. Data path and control unit synthesis. Pipelining and multiple instruction issue. Hierarchical memory systems. Input/output and interfacing. High-performance systems, including multiprocessors and multicomputers.

155A. Introduction to Computer Networks
(4) MOSER

Prerequisite: ECE 154 with a minimum grade of C-; and, Computer Science 12 or 60 with a minimum grade of C-.

Not open for credit to students who have completed Computer Science 176 or 176A, or ECE 155. Lecture, 3 hours; discussion, 1 hour.

Topics in this course include network architectures, protocols, wired and wireless networks, transmission media, multiplexing, switching, framing, error detection and correction, flow control, routing, congestion control, TCP/IP, DNS, email, World Wide Web, network security, socket programming in C/C++.

155B. Network Computing
(4) MOSER

Prerequisites: ECE 155A with a minimum grade of C-; and, Computer Science 5JA or 10 or 11JA with a minimum grade of C-.

Not open for credit to students who have completed Computer Science 176B or ECE 194W. Lecture, 3 hours; discussion, 1 hour.

Topics in this course include client/server computing, threads, Java applets, Java sockets, Java RMI, Java servlets, Java Server Pages, Java Database Connectivity, Enterprise Java Beans, Hypertext Markup Language, extensible Markup Language, Web Services, programming networked applications in Java.

156A. Digital Design with VHDL and Synthesis
(4) WANG

Prerequisite: ECE 152A with a minimum grade of C-. Lecture, 3 hours; laboratory, 3 hours.

Introduction to VHDL basic elements. VHDL simulation concepts. VHDL concurrent statements with examples and applications. VHDL subprograms, packages, libraries and design units. Writing VHDL for synthesis. Writing VHDL for finite state machines. Design case study.

156B. Computer-Aided Design of VLSI Circuits
(4) WANG

Prerequisite: ECE 156A with a minimum grade of C-. Lecture, 3 hours; laboratory, 3 hours.

Introduction to computer-aided simulation and synthesis tools for VLSI. VLSI system design flow, role of CAD tools, layout synthesis, circuit simulation, logic simulation, logic synthesis, behavior synthesis and test synthesis.

158. Digital Signal Processing
(4) GIBSON

Prerequisites: ECE 130A-B with a minimum grade of C- in both; open to EE majors only.

Lecture, 3 hours; laboratory, 3 hours.

Discrete signals and systems, convolution, z-transforms, discrete Fourier transforms, digital filters.

160. Multimedia Systems
(4) MELLIAR-SMITH

Prerequisites: upper-division standing; open to EE, computer engineering, computer science, and creative studies majors only. Lecture, 3 hours; laboratory, 3 hours.

Introduction to multimedia and applications, including WWW, image/video databases and video streaming. Covers media content analysis, media data organization and indexing (image/video databases), and media data distribution and interaction (video-on-demand and interactive TV).

162A. The Quantum Description of Electronic Materials
(4) BOWERS

Prerequisites: ECE 130A-B and 134 with a minimum grade of C- in all; open to EE and materials majors only.

Same course as Materials 162A. Lecture, 4 hours.

Electrons as particles and waves, Schrodinger's equation and illustrative solutions. Tunnelling. Atomic structure, the exclusion principle and the periodic table. Bonds. Free electrons in metals, periodic potentials and energy bands.

162B. Fundamentals of the Solid State
(4) COLDREN

Prerequisite: ECE 162A with a minimum grade of C-; open to EE and materials majors only.

Same course as Materials 162B. Lecture, 3 hours; discussion, 1 hour.

Crystal lattices and the structure of solids, with emphasis on semiconductors. Lattice vibrations, electronic states and energy bands. Electrical and thermal conduction. Dielectric and optical properties. Semiconductor devices: diffusion, p-n junctions and diode behavior.

162C. Optoelectronic Materials and Devices
(4) COLDREN

Prerequisites: ECE 162A-B with a minimum grade of C-; open to electrical engineering and materials majors only. Lecture, 3 hours; discussion, 1 hour.

Optical transitions in solids. Direct and indirect gap semiconductors. Luminescence. Excitons and photons. Fundamentals of optoelectronic devices: semiconductor lasers, Led's photoconductors, solar cells, photo diodes, modulators. Photoemission. Integrated circuits.

178. Introduction to Digital Image and Video Processing
(4) MANJUNATH

Prerequisites: open to EE, computer engineering, and computer science majors with upper-division standing. Lecture, 3 hours; discussion, 1 hour.

Basic concepts in image and video processing. Topics include image formation and sampling, image transforms, image enhancement, and image and video compression including JPEG and MPEG coding standards.

181A. Introduction to Robotics: Robot Mechanics
(4) PADEN

Same course as ME 170A.

Recommended preparation: ME 16. Lecture, 3 hours; laboratory, 3 hours.

Overview of robot kinematics and dynamics. Structure and operation of industrial robots. Robot performance: work space, velocity, precision, payload. Comparative discussion of robot mechanical designs. Actuators. Robot coordinate systems. Kinematics of position. Dynamics of manipulators.
(S; may not be offered every year)

181B. Introduction to Computer Vision
(4) MANJUNATH

Prerequisite: Upper-division standing.

Same course as Computer Science 181B.

Overview of computer vision problems and techniques for analyzing the content of images and video. Topics include image formation, edge detection, image segmentation, pattern recognition, texture analysis, optical flow, stereo vision, shape representation and recovery techniques, issues in object recognition, and case studies of practical vision systems.

181C. Introduction to Robotics: Robot Control
(4) PADEN

Prerequisite: ECE 2A-B-C with a minimum grade

of C-; or ME 104.

Same course as ME 170C. Lecture, 2 hours; laboratory, 4 hours.

Overview of robot control technology from open-loop manipulators and sensing systems, to single-joint servovalves and servomotors, to integrated adaptive force and position control using feedback from machine vision and touch sensing systems. Design emphasis on accurate tracking accomplished with minimal algorithm complexity. (F; may not be offered every year)

183. Nonlinear Phenomena
(4) TEEL

Prerequisites: Physics 105A or ME 163 or upper-division standing in EE.

Same course as Physics 106 and ME 169. Not open for credit to students who have completed ECE 163C. Lecture, 3 hours; discussion, 1 hour.

An introduction to nonlinear phenomena. Flows and bifurcations in one and two dimensions, chaos, fractals, strange attractors. Applications to physics, engineering, chemistry, and biology.

188A. Senior Electrical Engineering Project
(4) STAFF

Prerequisites: completion of at least 4 upper-division EE courses with a GPA of 3.0 or higher; open to EE and computer engineering, majors only; consent of instructor.

Student groups design a significant project based on the knowledge and skills acquired in earlier coursework and integrate their technical knowledge through a practical design experience. The project is evaluated through written reports, oral presentations, and demonstrations of performance.

188B. Senior Electrical Engineering Project
(4) STAFF

Prerequisites: ECE 188A with a minimum grade of C-; electrical engineering and computer engineering majors only.

Student groups design a significant project based on the knowledge and skills acquired in earlier coursework and integrate their technical knowledge through a practical design experience. The project is evaluated through written reports, oral presentations, and demonstrations of performance.

189A-B. Senior Computer Systems Project
(4-4) BUTNER

Prerequisite: consent of instructor; senior standing in computer engineering, computer science, or EE.

Not open for credit to students who have completed Computer Science 189.

Student groups design a significant computer-based project. Groups work independently with interaction among groups via interface specifications and informal meetings.

192. Projects in Electrical and Computer Engineering
(4) STAFF

Prerequisite: consent of instructor. Discussion, 2 hours; laboratory, 6 hours.

Projects in electrical and computer engineering for advanced undergraduate students.

193. Internship in Industry
(1-8) STAFF

Prerequisite: consent of department.

Must have a 3.0 grade-point-average. May not be used as departmental electives. May be repeated to a maximum of 12 units. Field, 1-8 hours.

Special projects for selected students. Offered in conjunction with engineering practice in selected industrial and research firms, under direct faculty supervision.

194AA-ZZ. Special Topics in Electrical and Computer Engineering
(1-5) STAFF

Prerequisite: consent of instructor. Variable hours.

Group studies intended for small number of advanced students who share an interest in a topic not included in the regular departmental curriculum. Topics covered include (check with department for quarters offered):

A. Circuits
AA. Micro-Electro-Mechanical Systems
B. Systems Theory
BB. Computer Engineering
C. Communication Systems
D. Control Systems
E. Signal Processing
F. Solid State
G. Fields and Waves
H. Quantum Electronics
I. Microwave Electronics
J. Switching Theory
K. Digital Systems Design
L. Computer Architecture
M. Computer Graphics
N. Pattern Recognition
O. Microprocessors and Microprocessor-based Systems
P. Simulation
Q. Imaging Systems and Image Processing
R. General
S. Speech
T. Robot Control
U. Optoelectronics
V. Scientific Computation
W. Computer Network
X. Distributed Computation
Y. Numerical Differential Equations
Z. Nanotechnology

196. Undergraduate Research
(2-4) STAFF

Prerequisites: upper-division standing; consent of instructor.

Must have a minimum 3.0 grade-point average for the preceding three quarters. May be repeated for up to 12 units. Not more than 4 units may be applied to departmental electives.

Research opportunities for undergraduate students. Students will be expected to give regular oral presentations, actively participate in a weekly seminar, and prepare at least one written report on their research.

199. Independent Studies in Electrical and Computer Engineering
(1-5) STAFF

Prerequisites: upper division standing; completion of two upper-division courses in electrical and computer engineering; consent of instructor.

Must have a minimum 3.0 grade-point average for the preceding three quarters. Students are limited to five units per quarter and 30 units total in all 98/99/198/199/199DC/199RA courses combined.

Directed individual study, normally experimental.

GRADUATE COURSES

201A. Electromagnetic Theory I
(4) DAGLI

Prerequisite: ECE 144. Lecture, 4 hours.

Basic concepts in electromagnetic theory, energy power, plane waves, guided waves, dielectric metallic waveguides, radiation, uniqueness, image theory, reciprocity, duality, equivalence principle, induction theorem.

205A. Information Theory
(4) ROSE

Prerequisites: ECE 140 or equivalent, or PSTAT 120A-B. Same course as Computer Science 225. Lecture, 4 hours.

Entropy, mutual information, and Shannon's coding theorems; lossless source coding, Huffman, Shannon-Fano-Elias, and arithmetic codes; channel capacity; rate-distortion theory, and lossy source coding; source-channel coding; algorithmic complexity and information; applications of information theory in various fields.

207. Research Projects or Independent Studies
(1-6) STAFF

Prerequisite: consent of instructor. Variable hours.

Graduate research projects or independent studies to be arranged between students and staff members. See M.S. degree requirements, plans 1 and 2, regarding number of units which may be used for M.S. degree.

210A. Matrix Analysis and Computation
(4) CHANDRASEKARAN

Prerequisite: consent of instructor.

Same course as Computer Science 211A, Mathematics 206A, ME 210A, Chemical Engineering 211A, and Geology 251A. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language. Lecture, 4 hours.

Graduate level-matrix theory with introduction to matrix computations. SVD's, pseudoinverses, variational characterization of eigen values, perturbation theory, direct and iterative methods for matrix computations.

210B. Numerical Simulation
(4) PETZOLD

Prerequisite: consent of instructor.

Same course as Computer Science 211B, Mathematics 206B, ME 210B, Chemical Engineering 211B and Geology 251B. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language. Lecture, 4 hours.

Linear multistep methods and Runge-Kutta methods for ordinary differential equations: stability, order and convergence. Stiffness. Differential algebraic equations. Numerical solution of boundary value problems.

210C. Numerical Solution of Partial Differential Equations—Finite Difference Methods
(4) STAFF

Prerequisite: consent of instructor.

Same course as Computer Science 211C, Mathematics 206C, ME 210C, Chemical Engineering 211C and Geology 251C. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language. Lecture, 4 hours.

Finite difference methods for hyperbolic, parabolic and elliptic PDEs, with application to problems in science and engineering. Convergence, consistency, order and stability of finite difference methods. Dissipation and dispersion. Finite volume methods. Software design and adaptivity.

210D. Numerical Solution of Partial Differential Equations—Finite Element Methods
(4) STAFF

Prerequisite: consent of instructor.

Same course as Computer Science 211D, Mathematics 206D, ME 210D, Chemical Engineering 211D and Geology 251D. Students should be proficient in basic numerical methods, linear algebra, mathematically rigorous proofs, and some programming language. Lecture, 4 hours.

Weighted residual and finite element methods for the solution of hyperbolic, parabolic and elliptical partial differential equations, with application to problems in science and engineering. Error estimates. Standard and discontinuous Galerkin methods.

211A. Engineering Quantum Mechanics I
(4) STAFF

Prerequisites: ECE 162A-B. Students must have some knowledge of linear algebra.

Same course as Materials 211A. Lecture, 4 hours.

Wave-particle duality; bound states; uncertainty relations; expectation values and operators; variational principle; eigenfunction expansions; perturbation theory I. Treatment matches needs and background of ECE and Materials students emphasizing solid state or quantum electronics.

211B. Engineering Quantum Mechanics II
(4) STAFF

Prerequisite: ECE 211A or Materials 211A, or ECE 215A or Materials 206A.

Same course as Materials 211B. Lecture, 4 hours.

Continuation of ECE 211A; symmetry and degeneracy; electrons in crystals, angular momentum; perturbation theory II; transition probabilities; quantized fields and radiative transitions; magnetic fields; electron spin; indistinguishable particles.

215A. Fundamentals of Electronic Solids I
(4) BROWN

Prerequisite: ECE 162A or 162B.

Same course as Materials 206A. Lecture, 4 hours.

Introduction into the physics of semiconductors for beginning engineering graduate students. Crystal structure. Reciprocal lattice and crystal diffraction. Electrons in periodic structures. Energy and bands. Semiconductor electrons and probes, Fermi statistics.

215B. Fundamentals of Electronic Solids II
(4) BROWN

Prerequisite: ECE 162A or 162B.

Same course as Materials 206B. Lecture, 4 hours.

Phonons, electron scattering, electronic transport, selected optical properties, heterostructures, effective mass, quantum wells, two-dimensional electron gas, quantum wires, deep levels, crystal binding.

216B. Defects in Semiconductors
(4) PETROFF

Prerequisites: ECE 162A-B.

Same course as Materials 216. Lecture, 3 hours.

Structural and electronic properties of elementar defects in semiconductors. Point defects and impurity complexes. Deep levels. Dislocations and grain boundary electronic properties. Measurement techniques for radiative and nonradiative defect centers.

217. Molecular Beam Epitaxy and Band Gap Engineering
(3) GOSSARD

Prerequisites: ECE 162A-B and 213.

Same course as Materials 217. Lecture, 3 hours.

Fundamentals and recent research developments in the growth and properties of thin crystalline films of electronic and optical materials by the process of molecular beam epitaxy. Artificially structured materials with quantized electron confinement and artificially engineered electronic band structure properties.

218A. Communication Electronics
(4) LONG

Prerequisites: ECE 137A-B or equivalent.

Analog communication circuits 1 MHz to 1 GHz with emphasis on receivers. S-parameter design techniques, nonideal components, distortion, amplifier design and characterization, system level analysis.

218B. Communication Electronics
(4) LONG

Prerequisite: ECE 218A.

Analog communication circuits 1 MHz to 1 GHz with emphasis on receivers. Design and evaluation of RF components: mixers, oscillators, PLL, IF amplifier, FM demodulator, frequency synthesis.

218C. High Speed Bipolar Mixed Signal and Communication IC Design
(4) RODWELL

Prerequisites: ECE 137A-B or equivalent; graduate standing.

Transistor and passive component models. Broadband amplifier design. Fast digital IC design at the transistor level. Circuit noise, signal/noise ratios, digital communication receiver sensitivity. Latched comparator design. Nyquist and oversampled analog-digital and digital-analog converters. Direct digital frequency synthesis. Fiber optic and microwave digital transceivers.

219. CMOS & RF INTEGRATED CIRCUIT DESIGN
(4) YUE

Prerequisite: ECE 137A and 137B.

Recommended Preparation: ECE 145A/218A and ECE 145B/218B.

Covers the design and analysis of radio-frequency integrated systems at the transistor level using state-of-the-art CMOS technology. Focuses on system-level trade-offs in transceiver design, practical RF circuit techniques, and physical understanding for device parasitics.

220A. Semiconductor Device Processing
(4) STAFF

Prerequisite: ECE 132 or equivalent.

Same course as Materials 215A. Lecture, 3 hours; discussion, 1 hour.

Intensive theoretical and laboratory instruction in solid-state device and integrated circuit fabrication. Topics include 1) semiconductor material properties and characterization; 2) phase diagrams; 3) diffusion; 4) thermal oxidation; 5) vacuum processes; 6) thin-film deposition; 7) scanning electron microscopy. Both gallium arsenide and silicon technologies are presented.

220B-C. Semiconductor Device Processing
(4-4) HU

Prerequisite: ECE 220A.

Same course as Materials 215B-C. Lecture, 3 hours; discussion 1 hour.

Continued theoretical and laboratory instruction in the fundamentals, the design, the fabrication, and the characterization of junction and field-effect devices. Topics will include bipolar characterization, design, fabrication, and testing. The laboratory effort initiated in ECE 220A will be continued in these two quarters.

221A. Semiconductor Device Physics I
(4) MISHRA

Prerequisites: ECE 132 and 162A-B. Lecture, 4 hours.

Band diagrams of P-N junctions and heterojunctions; current flow by drift and diffusion; bipolar transistors; recombination and generation. Schottky barriers; heterostructures.

221B. Semiconductor Device Physics II
(4) MISHRA

Prerequisites: ECE 215A and 221A. Lecture, 4 hours.

More advanced continuation of ECE 221A: field effect transistors, quantum wells and superlattices; tunneling; avalanche breakdown; physical limitations of bipolar and field effect transistors; two-dimensional current flow problems.

224A. VLSI Project Design
(4) BREWER

Prerequisite: ECE 124A or equivalent and ECE 124D/256C

Design, planning and layout of a CMOS/ Mixed-Signal VLSI Integrated Circuit for fabrication, characterization and test. Layout rules, topological, and physical issues in the design of integrated systems. Student teams plan, design and test a VLSI project.

224B. VLSI Project Testing
(4) BUTNER

Prerequisite: ECE 224A. Lecture, 2 hours; laboratory, 2 hours.

Test equipment and testing techniques. Methods for diagnosing design problems. Students perform laboratory testing of their fabricated designs from ECE 224A.

225. High Speed Digital Integrated Circuit Design
(4) BANERJEE

Prerequisite: ECE 124A or 137A. Lecture, 4 hours.

Advanced digital VLSI design: CMOS scaling, nanoscale issues including variability, thermal management, interconnects, reliability; non-clocked, clocked and self-timed logic gates; clocked storage elements; high-speed components, PLLs and DLLs; clock and power distribution; memory systems; signaling and I/O design; low-power design.

226. Level Set Methods
(4) GIBOU

Prerequisite: Computer Science 211C or Chemical Engineering 211C or ECE 210C or ME 210C.

Same course as Chemical Engineering 226, Computer Science 216, and ME 216.

Mathematical description of the level set method and design of the numerical methods used in its implementations (ENO-WENO, Godunov, Lax-Friedrich, etc.). Introduction to the Ghost Fluid Method. Applications in CFD. Materials Sciences, Computer Vision and Computer Graphics.

227A. Semiconductor Lasers I
(4) COLDREN

Prerequisites: ECE 162A-B-C or 144. Lecture, 4 hours.

Review of semiconductor physics, growth technology, and materials properties; double-heterostructure and quantum-well laser structures; carrier and photon rate equations; light vs. current characteristics; scattering and transmission matrices; compound cavity, distributed Bragg reflector, and distributed feedback lasers.

227B. Semiconductor Lasers II
(4) COLDREN

Prerquisites: ECE 227A and 215A. Lecture, 4 hours.

Gain and spontaneous emission vs. injection current in semiconductors; nonradiative recombination; strained-layer quantum wells. Dynamic characteristics of lasers including differential and large signal analysis of the rate equations; relative intensity noise and linewidth; carrier transport and feedback effects.

227C. Photonic Integrated Circuits
(4) COLDREN

Prerequisites: ECE 227A-B. Lecture, 4 hours.

Perturbation and coupled-mode analysis; DFB lasers revisited; directional couplers; modal excitation. Dielectric waveguide analysis techniques; waveguide radiation losses. Photonic integrated circuit examples, including tunable lasers with in-line gratings and contra- and co-directional couplers; ring lasers; numerical analysis techniques.

228A. Fiber Optic Communications
(4) BOWERS

Prerequisites: ECE 162A-B-C, 135, 144. Lecture, 4 hours.

Optical fiber structures and guided modes. Effect of dispersion, attenuation and fiber, nonlinearities. Basic transmission design including loss and rise time budgets. Optical transmission system essentials and requirements. Introduction to WDM and TDM components and technologies.

228B. Fiber Optic Components and Systems
(4) BOWERS

Prerequisite: ECE 228A. Lecture, 4 hours.

Photodetector design and receiver characteristics. Optical transmitters, optical amplifiers, optical isolators, optical switches, wavelength converters, regenerators, optical multiplexers, and demultiplexers. Advanced transmission link design and performance including bit error rate and signal to noise ratio and fiber transmission impairments.

228C. Optical Networks
(4) BOWERS

Prerequisite: ECE 228B. Lecture, 4 hours.

Introduction to optical network architectures including long-haul, wide-area, metro and access networks. First generation networks including SONET and Gigabit Ethernet. Second generation networks including optical circuit switched network concepts, control plane, protection switching, routing wavelength assignment, and network management and control.

229. Hybrid Systems
(4) HESPANHA

Prerequisite: graduate standing in mechanical engineering, chemical engineering, electrical & computer engineering, or computer science.

Recommended preparation: ECE 147A or similar course.

Introduction to systems that combine continuous dynamics with discrete logic. Topics include a modeling framework that combines elements from automata theory and differential equations, simulation tools, analysis and design techniques for hybrid systems and applications of hybrid control systems.

230A-B. Linear Systems I, II
(4-4) HESPANHA, BAMIEH

Prerequisites: ME 210A (for 230A): ECE 140; and, ECE 230A or ME 243A; and ME 210A (for 230B).

Same course as ME 243A-B. Lecture, 4 hours.

Internal and external descriptions. Solution of state equations. Controllability and observability realizations. Pole assignment, observers; modern compensator design. Disturbance localizations and decoupling. Least-squares control. Least-squares estimation; Kalman filters; smoothing. The separation theorem; LQG compensator design. Computational considerations. Selected additional topics.

232. Introductory Robust Control with Applications
(4) SMITH, KHAMMASH

Prerequisites: ECE 230A or ME 255A; and ECE 230B or ME 243B (may be taken concurrently).

Same course as ME 256.

Robust Control theory; uncertainty modeling; stabilty of systems in the presence of norm-bounded perturbations; induced norm performance problems;

structured singular value analysis; H-infinity control theory; model reduction; computer simulation based design projectinvolving practical problems.

234. Modeling, Identification, and Validation for Control
(4) SMITH

Prerequisite: ECE 230A. Lecture, 3 hours.

Parametric and non-parametric models, open and closed-loop identification, bias and variance effects, model order selection, probing signal design, subspace identification, closed-loop probing, autotuning, model validation, iterative identification and design.

235. Stochastic Processes in Engineering
(4) ILTIS

Prerequisites: ECE 140; graduate standing. Lecture, 4 hours.

A first-year graduate course in stochastic processes, including: review of basic probability; Gaussian, Poisson, and Wiener processes; wide-sense stationary processes; covariance function and power spectral density; linear systems driven by random inputs; basic Wiener and Kalman filter theory.

236. Nonlinear Control Systems
(4) TEEL

Same course as ME 236.

Recommended preparation: ECE 230A. Lecture, 4 hours.

Analysis and design of nonlinear control systems. Focus on Lyapunov stability theory, with sufficient time devoted to contrasts between linear and nonlinear systems, input-output stability and the describing function method.

237. Nonlinear Control Design
(4) TEEL

Prerequisite: ECE 236 or ME 236.

Same course as ME 237. Lecture, 4 hours.

Stabilizability by linearization and by geometric methods. State feedback design and input/output linearization. Observability and output feedback design. Singular perturbations and composite control. Backstepping design of robust controllers for systems with uncertain nonlinearities. Adaptive nonlinear control.

238. Advanced Control Design Laboratory
(4) SMITH

Prerequisites: ECE 230A; and, ECE 232A or ECE 237 or ME 237 or ECE 249 or ME 270A or Chemical Engineering 252. Lecture, 2 hours; laboratory, 6 hours.

A laboratory course requiring students to design and implement advanced control systems on a physical experiment. Experiments from any engineering or scientific discipline are chosen by the student.

240A. Optimal Estimation and Filtering
(4) SHYNK

Prerequisites: ECE 140 and 210A. Lecture, 4 hours.

Optimal estimation concepts and theory (minimum variance, least-squares, and maximum likelihood estimation), optimal recursive algorithms for discrete- and continuous-time filtering of noisy signals and data. Wiener and Kalman filters, stability of recursive optimal filtering algorithms, modeling errors in recursive filters.

241. Multimedia Compression
(4) GIBSON

Prerequisites: ECE 140 or 235; and ECE 158.

Not open for credit to students who have completed MAT 221. Lecture, 4 hours.

Covers the principle standards of speech, audio, still image and video compression with emphasis on system performance, key underlying algorithms and technologies, current applications and the projected future evolution of the standards.

242. Digital Signal Compression
(4) ROSE

Prerequisites: ECE 140 or 235; and ECE 146B. Lecture, 3 hours.

Principles and techniques of signal compression systems. Basic quantization theory, linear prediction, predictive coding, transform and subband coding, entropy coding, and vector quantization. Techniques and algorithms for efficient trade-offs between fidelity, bit-rate, and complexity. Applications to speech, audio, image and video compression.

243A. Digital Communication Theory
(4) SHYNK

Prerequisite: ECE 146B. Lecture, 4 hours.

Review of probability and random waveforms, optimum receiver principles, efficient signaling, bounds on error probability, convolutional coding, channel capacity, emphasis on geometric approach to signal description.

243B. Advanced Digital Communication Theory
(4) SHYNK

Prerequisite: ECE 243A. Lecture, 4 hours.

Bandlimited channels and optimum receiver for ISI channels; linear, decision-feedback, blind, and adaptive equalization; multichannel and multicarrier systems; spread-spectrum signals; direct sequence and frequency hopped; fading multipath channels and diversity techniques; multiuser communications.

245. Adaptive Filter Theory
(4) SHYNK

Prerequisites: ECE 140, 158, and 210A (may be taken concurrently). Lecture, 4 hours.

Theory and analysis of adaptive filters. Optimal filtering, linear prediction, method of least squares. Steepest-descent and Newton search methods, gradient estimation, LMS adaptive algorithm, recursive least squares. Gradient and least-squares lattice algorithms for joint-process estimation. Convergence analysis, stability conditions, time constants, misadjustment. (offered in alternate years.)

247. System Identification
(4) STAFF

Prerequisite: ECE 230A. Lecture, 4 hours.

On-line identification of continuous- and discrete-time systems. Linear parameterizations. Continuous gradient and least squares algorithms. Stability, persistent excitation and parameter convergence. Robust algorithms for imperfect models. Averaging. Discrete-time equation-error identifiers. Output-error methods.

248. Kalman and Adaptive Filtering
(4) STAFF

Prerequisites: ECE 210A, 230A and 235 (may be taken concurrently). Lecture, 4 hours.

Least-squares estimation for processes with state-space models. Wiener filters and spectral factorization. Kalman filters, smoothing and square-root algorithms. Steady-state filters. Extended Kalman filters for non-linear models. Fixed-order and order-recursive adaptive filters.

249. Adaptive Control Systems
(4) KOKOTOVIC

Prerequisites: ECE 236 and 247. Lecture, 4 hours.

Models of plants with unknown parameters. Boundedness properties of parameter update laws. Adaptive linear control. Stability and robustness to modeling errors and disturbances. Backstepping state-feedback design of direct adaptive nonlinear control. Output-feedback design. Nonlinear swapping. Indirect adaptive nonlinear control.

250. Wireless Communication and Networking
(4) RODOPLU

Prerequisites: ECE 155A and 146A. Lecture, 4 hours.

Overview of wireless networks, characteristics of wireless medium, physical layer operation (spread spectrum, UWB, OFDM, adaptive modulation, MIMO channel), cellular planning, mobility management, energy-efficient networking, GSM, CDMA, wireless LANs, ad hoc networks, wireless geolocation systems.

252B. Computer Arithmetic
(4) PARHAMI

Prerequisites: ECE 152A-B. Lecture, 4 hours.

Standard and unconventional number representations. Design of fast two-operand and multi-operand adders. High-speed multiplication and division algorithms. Floating-point numbers, algorithms, and errors. Hardware algorithms for function evaluation. Pipelined, digit-serial, and fault-tolerant arithmetic processors.

253. Embedded System Design
(4) BREWER

Lecture, 4 hours.

Design and application of embedded computing systems, particular attention paid to computation system design in highly constrained environments. System synthesis and modeling techniques including partitioning, scheduling, control and data flow analysis and functional representation. Embedded project design.

254A. Advanced Computer Architecture: Supercomputers
(4) MELLIAR-SMITH

Prerequisite: ECE 154. Lecture, 4 hours.

Design and application aspects of high-performance uniprocessors and shared memory multiprocessors. Memory design issues: cache memories, address translation, interleaving. Processor design issues: instruction sets, pipelining, vector processing. Software issues: explicit/implicit vectorization, vector-processing languages, optimizing compilers. Case studies of designs and applications.

254B. Advanced Computer Architecture: Parallel Processing
(4) PARHAMI

Prerequisite: ECE 254A. Lecture, 4 hours.

The nature of concurrent computations. Idealized models of parallel systems. Practical realization of concurrency. Interconnection networks. Building-block parallel algorithms. Algorithm design, optimality, and efficiency. Mapping and scheduling of computations. Example multiprocessors and multicomputers.

254C. Advanced Computer Architecture: Distributed Systems
(4) MELLIAR-SMITH

Prerequisite: ECE 254A.

Multicomputers and distributed architectures. Message-based asynchronous computations. Distributed algorithms and their performance. Hardware issues: nodes, links, and communication mechanisms. Control issues: synchronization, global state determination, distributed consensus, and fault tolerance. Software issues: operating systems and languages.

255A. VLSI Testing Techniques
(4) CHENG

Prerequisites: ECE 152A, knowledge of C language, data structures and algorithms. Lecture, 4 hours.

Concepts, algorithms and design techniques for VLSI testing. Fault modeling, fault simulation, automatic test generation, design for testability, built-in self test, testability analysis, delay testing and synthesis for testability.

255B. VLSI Design Validation
(4) WANG

Prerequisites: ECE 255A, knowledge of C language, data structures and algorithms; consent of instructor. Lecture, 4 hours.

Theories and concepts in verification. Verification tools and methodologies. Functional verification, equivalence checking, symbolic simulation, error modeling, verification coverage, silicon debug, on-chip validation, test and verification.

256A. Introduction to Design Automation
(4) MAREK-SADOWSKA

Prerequisites: ECE 124A or ECE 224A; knowledge of C language; Algorithms and Data Structures, equivalent to Computer Science 130A-B. Lecture, 3 hours; laboratory, 2 hours.

Overview of physical level design automation. Partitioning, placement, routing and structured design of VLSI and PC-board structures. Techniques will include graph theoretic algorithms, integer linear programming, force-directed and simulated annealing neuristics.

256B. Logic Design Automation
(4) BREWER

Prerequisite: ECE 256A. Lecture, 3 hours; laboratory, 2 hours.

CAD algorithms for VLSI logic and module level design. Special attention paid to timing, area, and power trade-offs. Cell design systems and associated lab with state of the art VLSI design tools. (W)

256C. Advanced VLSI Architecture and Design
(4) STAFF

Prerequisite: ECE 124A or equivalent or ECE 256A or 256B

Large scale VLSI design with attention to performance constraints in real-world designs. Topics include: circuit modeling, communication parasitics, architecture optimization, and packaging. Large scale project will be fabricated using silicon compilation tools.

256D. Algorithmic Logic Synthesis
(4) MAREK-SADOWSKA

Prerequisite: ECE 256A. Lecture, 4 hours.

Companion course for ECE 256B. Algorithmic extension of logic synthesis and techniques. Topics covered include: two and multilevel minimization, technology mapping, logic partitioning, and testable logic.

257A. Fault Tolerant Computing
(4) PARHAMI

Prerequisites: ECE 152A-B. Lecture, 3 hours.

Basic concepts of dependable computing. Reliability of nonredundant and redundant systems. Dealing with circuit-level defects. Logic-level fault testing and tolerance. Error detection and correction. Diagnosis and reconfiguration for system-level malfunctions. Degradation management. Failure modeling and risk assessment.

258A. Advanced Digital Signal Processing
(4) STAFF

Prerequisite: ECE 158. Lecture, 4 hours.

Digital filter design, discrete random signals, effects of finite word length arithmetic, fast Fourier transform and applications, power spectrum estimation.

258B. Multirate Digital Signal Processing
(4) STAFF

Prerequisites: ECE 158 and ECE 258A. Lecture, 4 hours.

Multirate digital filter theory, polyphase decomposition, decimator and interpolar design, efficient implementations, orthogonal transforms, wavelet transform, analysis and synthesis filter banks, quadrature mirror filter banks, transmultiplexer, subhand decomposition, applications.

258C. VLSI Digital Signal Processing Systems
(4) STAFF

Prerequisites: ECE 158 and ECE 258A. Lecture, 4 hours.

Characteristics and representations of signal processing programs, iteration bound, pipelining and parallel processing, retiming and unfolding transformations, fast convolution algorithms, algorithmic strength reductions in filters and transforms. (offered every even-numbered year)

259A. Digital Speech Processing
(4) RABINER

Prerequisite: ECE 158 and ECE 242. Lecture, 4 hours.

Speech sounds, acoustic phonetics, speech production and perception. Digital filter modeling of the vocal tract as a lossless tube. Short-time characteristics of speech in the time and frequency domains. Waveform and linear predictive coding of speech. Speech synthesis and recognition.

259B. Fundamentals of Speech Recognition
(4) RABINER

Prerequisite: ECE 158 and ECE 242. Lecture, 4 hours.

Course covers the fundamental design principles of automatic speech recognition systems, including speech detection, time alignment and normalization (including dynamic time warping methods), distortion measures, the Hidden Markov Model (HMM), grammar networks and the use of Finite State Network representations. (Offered alternate years.)

260A. Principles of Quantum Electronics
(4) YEH

Prerequisite: ECE 144A or 162C. Lecture, 4 hours.

Energy levels in atoms, ions, and molecules. Interaction between radiation and quantized systems. Stimulated emission devices. Optical resonators. Lasers. (offered alternate years)

267. Confined Electrons and Photons in Semiconductor Structures
(3) PETROFF

Prerequisite: Materials 162A-B or ECE 162A-B. Same course as Materials 267. Lecture, 3 hours.

The properties of 1D, 2D and 3D confined electrons in semiconductor are reviewed. Properties of photons in microcavities and photonic crystals are introduced. Applications of photonic crystals to light extraction and modifications of the emitter properties are developed.

270. Noncooperative Game Theory
(4) HESPANHA

Lecture, 4 hours.

Formulation of problems as mathematical games and provides the basic tools to solve them. Covers both static and dynamic games. Intended for graduate students (but is not restricted to) in communications, controls, signal processing, and computer science.

271A. Principles of Optimization
(4) CHANDRABEKARAN

Prerequisite: ECE 210A (may be taken concurrently). Lecture, 4 hours.

Linear programming: simplex and revised simplex method, duality theory, primal-dual algorithms, Karmarkar's algorithm. Network flow problems: max-flow/min-cut theorem, Ford-Fulkerson algorithm, shortest path algorithms. Complexity and NP-completeness theory: the classes of P and NP, reductions between NP-complete problems, pseudopolynomial and approximation algorithms.

271B. Numerical Optimization Methods
(4) STAFF

Prerequisite: ECE 210A. Lecture, 4 hours.

Unconstrained nonlinear problems: basic properties of solutions and algorithms, global convergence, convergence rate, and complexity considerations. Constrained nonlinear problems: basic properties of solutions and algorithms. Primal, penalty and barrier, cutting plane, and dual methods. Computer implementations.

271C. Optimal Control of Dynamic Systems
(4) BAMIEH

Prerequisite: ECE 230A or ME 243A or equivalent

Calculus of variations and Gateaux and Frechet derivatives. Optimization in dynamic systems and Pontryagin's principle. Invariant Imbedding and deterministic and stochastic Dynamic Programming. Numerical solutions of optimal control problems. Min-max problems and differential games. Extensive treatment of Linear Quadratic Problems.

277B. Pattern Recognition
(4) ROSE

Prerequisites: ECE 130C and 140. Lecture, 4 hours.

Principles and design of pattern recognition systems. Statistical classifiers: discriminant functions; Bayes, minimum-risk, k-nearest neighbors, perceptrons. Clustering and estimation; criteria; k-means, fuzzy, hierarchical, graph-theoretic, simulated and deterministic annealing; maximum likelihood and Bayesian methods; nonparametric methods. Overview of applications.

278A. Digital Image Processing
(4) MANJUNATH

Prerequisite: ECE 158 or ECE 178. Lecture, 3 hours; laboratory, 3 hours.

Two-dimensional signals and systems. Two-dimensional Fourier and z-transforms. Discrete Fourier transform, two-dimensional digital filters. Image processing basics, image enhancement and restoration. Special image processing software available for laboratory experimentation.

278C. Imaging Systems
(4) LEE

Prerequisites: ECE 158 and 178. Lecture, 4 hours.

Generalized holography, backward techniques, resolution limit, X-ray tomography, diffraction tomography, NMR imaging, synthetic-aperture radar, active sonar imaging, acoustic microscopy, imaging algorithms, motion estimation and tracking.

279. Computer System Performance Evaluation
(4) STAFF

Prerequisite: ECE 140, ECE 154, and Computer Science 170.

Overview of the evaluation of comput er system performance. Measurement, simulation, and analytic techniques for performance analysis. System work load characterization. Examples of performance evaluation for system selection, tuning, and design. Evaluation of program performance.

281B. Advanced Topics in Computer Vision
(4) MANJUNATH

Prerequisite: ECE 181B. Lecture, 3 hours. Same course as Computer Science 281B.

Advanced topics in computer vision: image sequence analysis, spatiotemporal filtering, camera calibration and hand-eye coordination, robot navigation, shape representation, physically-based modeling, multi-sensory fusion, biological models, expert vision systems, and other topics selected from recent research papers.

282. Error Correcting Codes
(4) ROSE

Prerequisite: ECE 130C or 140. Lecture, 3 hours.

Principles and techniques for combating channel errors in data transmission or storage. Introduction to Galois fields. Linear block codes (particularly Hamming, BCH, Reed-Solomon). Convolution codes. Encoding and decoding algorithms (including spectral methods, maximum likelihood and Viterbi decoding.)

290. Ethics in Academic and Industrial Research
(2) SMITH

Prerequisite: consent of instructor. Lecture, 2 hours.

Case study/analysis format addressing ethical issues in research conduct: moral reasoning, authorship, scholarship, copyright, misconduct, fraud, falsification, mentor/protege relationships, confidentiality, patents, consulting, conflicts of interest, funding and control of research, reviewing and editing, sexual relationships in the workplace.

293. Internship in Industry
(1-6) STAFF

Prerequisite: consent of department. May be repeated to a maximum of 6 units. Variable hours.

Special projects for selected students. Offered in conjunction with engineering practice in selected industrial and research firms, under direct faculty supervision.

295. Group Studies: Controls, Dynamical Systems, and Computation
(1) STAFF

Same course as Chemical Engineering 295, Computer Science 592, and ME 295. Seminar, 1 hour.

A series of weekly lectures given by university staff and outside experts in the fields of control systems, dynamical systems, and computation.

493. Internship in Industry
(1-12) STAFF

Prerequisite: Graduate student standing; open to EE and computer engineering majors only.

Special projects for selected students. Offered in conjunction with engineering practice in selected industrial and research firms, under direct faculty supervision.

502. Teaching of Electrical and Computer Engineering
(1-4) STAFF

Open to electrical and computer engineering teaching assistants only. No unit credit allowed toward advanced degree. Variable hours.

Procedures and techniques for teaching electrical engineering or computer engineering gained through actual teaching of lecture courses, leading discussion sections, and/or teaching engineering laboratories. Meetings will be held as needed to discuss problems, methods, and procedures.

594AA-ZZ. Special Topics in Electrical and Computer Engineering
(1-5) STAFF

Prerequisites: consent of instructor and graduate status. May be repeated for credit if there is no duplication of course content. Seminar, 1-5 hours.

Instruction in these courses may be carried out by lecture, or by laboratory, or by a combination of these. These courses provide a study of topics of current interest in various areas of electrical and computer engineering. Special topics are coded as follows (check with department for quarters offered):

A. Circuits
AA. Micro-Electro-Mechanical Systems
B. Systems Theory
BB. Computer Engineering
C. Communication Systems
D. Control Systems
E. Signal Processing
F. Solid State
G. Fields and Waves
H. Quantum Electronics
I. Microwave Electronics
J. Switching Theory
K. Digital Systems Design
L. Computer Architecture
M. Computer Graphics
N. Pattern Recognition
O. Microprocessors and Microprocessor-based Systems
P. Simulation
Q. Imaging Systems and Image Processing
R. General
S. Speech
T. Robot Control
U. Optoelectronics
V. Scientific Computation
W. Computer Network
X. Distributed Computation
Y. Numerical Differential Equations
Z. Nanotechnology

595AA-ZZ. Group Studies in Electrical and Computer Engineering
(1) STAFF

Prerequisite: consent of instructor.

No unit credit allowed toward degree. May be repeated for enrollment credit if there is no duplication of course content. Seminar, 1 hour.

Instruction in research group meetings carried out by lecture, by laboratory, or by a combination of the two. Courses provide a critical review of research in various areas of electrical and computer engineering.

596. Directed Research
(2-12) STAFF

Research, either experimental or theoretical, May be undertaken by properly qualified graduate students under the direction of a faculty member.

597. Individual Studies for M.S. Comprehensive Examinations and Ph.D. Examinations
(1-12) STAFF

No unit credit allowed toward advanced degree. Enrollment limited to 24 units per exam.

Individual studies for M.S. comprehensive examinations and Ph.D. examinations. Maximum of 12 units per quarter. S/U grading. Instructor is normally student's major professor or chair of doctoral committee.

598. Master's Thesis Research and Preparation
(1-12) STAFF

Prerequisite: consent of graduate advisor.

For research underlying the thesis and writing of the thesis.

599. Ph.D. Dissertation Research and Preparation
(1-12) STAFF

Prerequisite: consent of chair of student's doctoral committee.

Research and preparation of dissertation.