ELECTRICAL AND ECE COMPUTER ENGINEERING

Department of Electrical and Computer Engineering
College of Engineering

101 Introduction to Electrical and Computer Engineering
Fall, Spring. 1(0-3)
Basic stamp microcontroller. Passive circuit elements. Sensors. Boe-bot and Sumo-bot. Survey of electrical and computer engineering careers. Resume preparation. Design day competition.

201 Circuits and Systems I
Fall, Spring, Summer. 3(3-0) P: ((CSE 131 or concurrently) or (CSE 231 or concurrently) or (EGR 102 or concurrently)) and ((MTH 234 or concurrently) or (MTH 254H or concurrently) or (LB 220 or concurrently)) SA: ECE 200
Resistive circuits. Loop and modal analysis. Network theorems, dependent sources. Capacitor and inductor circuits. Transient analysis. Introduction to computer-aided design.

202 Circuits and Systems II
Fall, Spring, Summer. 3(3-0) P: ECE 201 and ((MTH 235 or concurrently) or (LBS 119 or concurrently) or (MTH 255H or concurrently)) SA: ECE 360
Sinusoidal steady-state response. Laplace transforms. S-Domain circuit analysis. Frequency response. Fourier series. Mutual inductance. Power in sinusoidal steady state.

203 Electric Circuits and Systems Laboratory
Fall, Spring, Summer. 1(0-3) P: ECE 202 or concurrently
Electrical test equipment and measurement fundamentals. Circuit and filter design using integrated circuit amplifiers.

230 Digital Logic Fundamentals
Fall, Spring, Summer. 3(3-0) P: CSE 131 or CSE 231 or EGR 102 SA: ECE 330
Binary information. Switching algebra, combinational logic, minimization. Programmable logic devices. Sequential system fundamentals and state machines. Arithmetic operations and circuits. Memory elements and systems. Design tools. Design problems.

280 Electrical Engineering Analysis
Fall, Spring. 3(3-0) P: MTH 234 and (ECE 201 or concurrently)
Application of linear algebra, complex numbers, vectors, probability, and random processes to elementary problems in electrical and computer engineering. Application to signals, systems, noise, electromagnetics, and reliability. Modeling using standard software packages.

302 Electronic Circuits
Fall, Spring. 3(3-0) P: ECE 202 and (ECE 280 or concurrently) R: Open to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and Engineering. SA: EE 302
Volt-ampere characteristics of diodes and transistors. Modeling using SPICE software. Differential, multistage, and integrated circuit amplifiers. High frequency effects.

303 Electronics Laboratory
Fall, Spring. 1(0-3) P: ECE 203 and (ECE 302 or concurrently) and (ECE 280 or concurrently) R: Open to students in the Department of Computer Science and Engineering or in the Department of Electrical and Computer Engineering. SA: EE 303
Electronic test equipment and measurement fundamentals. Circuit design using diodes, transistors, integrated circuits, and sensors.

305 Electromagnetic Fields and Waves I
Fall, Spring, Summer. 4(4-0) P: ((MTH 235 or concurrently) or (LB 119 or concurrently) or (MTH 255H or concurrently)) and (PHY 184 or PHY 184B or PHY 234B) and (ECE 280 and (ECE 202 or concurrently)) R: Open to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and Engineering. SA: EE 305
Transient and time-harmonic transmission lines. Smith charts. Two-port networks. Maxwell's equations. Force, energy, and power. Plane electromagnetic waves. Guided waves.

313 Control Systems
Fall, Spring. 3(3-0) P: (ECE 202 or ECE 345) and ECE 280 R: Open to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and Engineering. SA: EE 413, ECE 413
Analysis and design of control systems using transfer functions and state variable methods.

320 Energy Conversion and Power Electronics
Fall, Spring. 3(3-0) P: ECE 302 and ECE 303 and ECE 305 R: Open to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and Engineering. SA: EE 320
Power and energy. Magnetics and transformers. Elementary and induction machines. Power semiconductors. Controlled rectifiers and inverters. Power supplies and motor drives.

331 Microprocessors and Digital Systems
Fall, Spring. 4(3-3) P: CSE 232 or (EGR 102 and (CSE 251 or concurrently) and ECE 230) R: Open to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and Engineering. SA: EE 331
Microcomputers. Microprocessor architecture. Addressing modes. Assembly language programming. Parallel and serial input and output. Interfacing. Interrupts. Peripheral device controllers. Applications and design.

345 Electronic Instrumentation and Systems
Fall, Spring, Summer. 3(2-3) P: (MTH 235 or MTH 255H or LBS 119) and ((PHY 184 or PHY 184B or PHY 234B) and completion of Tier I writing requirement) R: Open only to students in the College of Engineering with the exception of students in the Department of Electrical and Computer Engineering. SA: EE 345
Electrical and electronic components, circuits and instruments. Circuit laws and applications, frequency response, operational amplifiers, semi-conductor devices, digital logic, counting circuits.

366 Introduction to Signal Processing
Fall, Spring, Summer. 3(3-0) P: ECE 202 and ECE 280 R: Open to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and Engineering. SA: ECE 360
Continuous- and discrete-time signal analysis fundamental to modern signal processing and communications technologies. Fourier and spectral analysis of signals. Elementary modulation techniques. Filtering and channel models. The z-transform. Introduction to random processes and noise in discrete time. Application examples.

390 Ethics, Professionalism and Contemporary Issues
Fall, Spring. 1(1-0) P: Completion of Tier I Writing Requirement R: Open to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and Engineering.
Ethical theories and codes of ethics. Role of the engineer in society. Contemporary issues in electrical and computer engineering. Professionalism.

402 Applications of Analog Integrated Circuits
Spring. 4(3-3) P: ECE 302 and ECE 303 R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering. SA: EE 484, ECE 484
Circuit design using analog integrated circuits. SPICE macromodeling. Operational amplifiers, comparators, timers, regulators, multipliers and converters. Design project with hardware and software verification.

404 Radio Frequency Electronic Circuits
Fall. 4(3-3) P: ECE 302 and ECE 303 and ECE 305 R: Open to students in the Department of Electrical and Computer Engineering.
Radio frequency active and passive circuit design. Impedance matching for specific bandwidths. Tuned amplifier, filter, mixer, and oscillator analysis. High frequency measurements and equipment.

405 Electromagnetic Fields and Waves II
Fall. 4(3-3) P: ECE 305 R: Open only to juniors or seniors or graduate students in the Electrical Engineering major and to juniors or seniors in the Computer Engineering major. SA: ECE 435
Microwave networks. Scattering parameters. Solutions to Coulomb's law, Gauss' Law and the wave equation. Planar transmission lines. Antennas. Waveguides and cavities. Measurement of the properties of antennas and microwave networks.

407 Electromagnetic Compatibility
Spring. 4(3-3) P: ECE 202 and ECE 305 and ECE 366 R: Open only to juniors or seniors or graduate students in the Electrical Engineering major and juniors or seniors in the Computer Engineering major.
Electromagnetics for electrical systems. Signals and spectra. Regulations. Radiated and conducted emissions. Conducted and radiated immunity. Mitigation techniques.

410 VLSI Design
Fall, Spring. 4(3-3) P: ECE 302 and ECE 303 and ECE 230 R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering or Department of Computer Science and Engineering. SA: EE 410
Digital integrated circuit design fundamentals. Design specifications: functionality, performance, reliability, manufacturability, testability, cost. Standards, silicon compilers, foundries. Design layout rules, rule checking. Circuit extraction, simulation, verification. Team-based design.

411 Electronic Design Automation
Fall, Spring. 4(3-3) P: CSE 320 or ECE 331 R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering or Department of Computer Science and Engineering. SA: EE 411
Electronic circuit design hierarchy and the role of methodology. Application specific integrated circuits. Hardware description languages. Behavioral and structural circuit modeling. Design algorithms and design tools. Design projects.

412 Introduction to Mixed-Signal Circuit Design
Fall. 4(3-3) P: ECE 302 R: Open to students in the Department of Electrical and Computer Engineering. SA: ECE 418
Mixed-signal circuit design. Analog and digital very large scale integration (VLSI). Design and analysis of switched capacitor circuits. Design and analysis of digital-to-analog converters of analog-to-digital converters. Performance analysis and testing of data converters.

415 Computer Aided Manufacturing
Fall. 3(2-3) P: ECE 313 or ME 451 R: Open only to juniors or seniors in the Manufacturing Engineering major. SA: EE 415
CAD/CAM fundamentals, programmable controllers, numerical control, NC part programming, sensors, data acquisition systems.

416 Digital Control
Spring. 3(2-3) P: ECE 303 and ECE 313 R: Open only to juniors or seniors in the Electrical Engineering major or Computer Engineering major.
State-space models. Analysis and design of control systems using state models. Digital control. Discrete-models of sampled-data systems. Quantization effects and sample-rate selection. System identification. Simulation of nonlinear control systems. Examples of nonlinear phenomena. State of the art of control engineering. Control laboratory.

420 Machines and Power Laboratory
Spring. 1(3-0) P: (ECE 320 or concurrently) or (ECE 423 or concurrently) R: Open only to juniors or seniors in the Department of Electrical and Computer Engineering.
Experimental investigation of machines, power electronics and power systems. Experimental verification of material found in introductory courses on energy conversion with extension to power electronics and power systems.

423 Power System Analysis
Spring. 3(3-0) P: ECE 320 R: Open only to juniors or seniors in the Department of Electrical and Computer Engineering. SA: ECE 421
Synchronous machines. Models and measurements of power components. Symmetrical components. Short-circuit analysis and equipment protection. Load flow. Voltage and frequency control. Operation and planning of power systems.

442 Introduction to Communication Networks
Fall. 3(3-0) P: ECE 280 or STT 351 R: Open to undergraduate students in the Department of Electrical and Computer Engineering.
Fundamental theories of communication networks with emphasis on statistical performance modeling of Medium Access Control, Data Link Control, Routing and Transport Layer protocols. Network design and analysis using basic probabilistic and statistical tools, including Little's formula, Markov Chain, and introductory queuing theory. Discrete event simulation projects.

445 Biomedical Instrumentation
Fall of even years. 3(2-3) P: ECE 303 or ECE 345 R: Open to students in the College of Engineering.
Fundamentals of biomedical measurements. Sensors. Instrumentation electronics. Biomedical devices, applications and case studies. Commercialization of biomedical technology. Hands-on experience with sensors, instrumentation electronics, and biomedical devices.

446 Biomedical Signal Processing
Fall of odd years. 3(3-0) P: ECE 366 RB: Basic linear systems and probability theory. R: Open to students in the College of Engineering. Not open to students with credit in ECE 466.
Deterministic and random digital signal processing theory in the context of biomedical applications with computer projects on the analysis of real physiologic signals.

447 Introduction to Biomedical Imaging
Spring of even years. 3(3-0) P: ECE 366 RB: ECE 305 R: Open to students in the College of Engineering.
Fundamental mathematics, physics, engineering principles, and applications of biomedical imaging techniques including ultrasound, x-ray imaging, computed tomography, nuclear medicine, including PET and SPECT, and magnetic resonance imaging.

448 Modeling and Analysis of Bioelectrical Systems
Spring of odd years. 3(3-0) P: ECE 366 or ECE 313 R: Open to students in the College of Engineering.
Basics of deterministic and stochastic linear systems , Principles of biophysics and electrophysiology, Theory and principles of system identification, methods to formulate dynamic mathematical and computer models of bioelectrical systems, Applications to neural systems and neuroprosthetics.

457 Communication Systems
Spring. 3(3-0) P: ECE 302 and ECE 366 R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering. SA: EE 457
Representation and processing of signals in the presence of noise. System performance. Modulation, detection, and coding of information. System design applications in radar, sonar, radio, television, satellite communications, digital telephony, and wireless systems.

458 Communication Systems Laboratory
Spring. 1(0-3) P: ECE 303 and (ECE 457 or concurrently) SA: EE 458
A projects laboratory in communication systems.

466 Digital Signal Processing and Filter Design
Fall. 3(3-0) P: ECE 366 R: Open to seniors or graduate students in the College of Engineering. SA: EE 466 Not open to students with credit in ECE 446.
Discrete Fourier transforms, sampling theorem, circular convolution, Z-transforms. Design of infinite impulse resistance filters using prototypes and algorithmic methods. Design of finite impulse resistance filters by windowing, frequency sampling.

474 Principles of Electronic Devices
Fall, Spring. 3(3-0) P: ECE 302 and ECE 305 SA: EE 474
Energy levels in atoms. Crystal properties, energy bands and charge carriers, semiconductors, transport properties of bulk materials. P-n junction diodes, bipolar transistors, field effect transistors.

476 Electro-Optics
Fall, Summer. 4(3-3) P: ECE 302 and ECE 303 and ECE 305 R: Open only to juniors or seniors or graduate students in the Electrical Engineering major and juniors or seniors in the Computer Engineering major. SA: EE 476
Operational theory, characteristics and applications of optical components, light emitting diodes, lasers, laser diodes, photodetectors, photovoltaics, fiber optics, optical modulators and non-linear optical devices.

477 Microelectronic Fabrication
Fall. 3(2-3) P: ECE 474 or concurrently R: Open only to juniors or seniors in the Department of Electrical and Computer Engineering. SA: ECE 483
Microelectronic processing fundamentals and simulations. Comparison of current microfabrication technologies and their limitations.

480 Senior Design
Fall, Spring. 4(3-3) P: (ECE 303 and ECE 313 and ECE 320 and ECE 331 and ECE 366 and (ECE 390 or concurrently)) or ((CSE 410 and (ECE 390 or concurrently)) and completion of Tier I writing requirement) R: Open to seniors in the Department of Electrical and Computer Engineering or in the College of Engineering. SA: ECE 481, ECE 482, ECE 483
Electrical engineering and computer engineering senior design experience involving contemporary design tools and practices, engineering standards, cross-functional teaming, oral and written technical communication, and lifelong learning.

490 Independent Study
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 3 credits in all enrollments for this course. R: Approval of department. SA: EE 490
Independent study of a topic in electrical engineering or computer engineering.

491 Special Topics
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to students in the Department of Electrical and Computer Engineering. SA: EE 491
Investigation of special topics in electrical engineering or computer engineering.

499 Undergraduate Research
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 4 credits in all enrollments for this course. R: Approval of department. SA: EE 499
Independent undergraduate research in contemporary areas of electrical engineering or computer engineering.

801 Independent Study
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 3 credits in all enrollments for this course. R: Approval of department. SA: EE 801
Independent investigation of a topic in electrical engineering compatible with the student's prerequisites, interest, and ability.

802 Selected Topics
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 21 credits in all enrollments for this course. SA: EE 802
Investigation of special topics in electrical engineering.

809 Algorithms and Hardware Implementation
Fall. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Electrical and Computer Engineering. SA: EE 809
Arithmetic, signal processing, and image processing algorithms. Array structures: systolic architecture, data flow structure, neural network architecture. Performance analysis.

810 Radio Frequency Integrated Circuits
Fall. 3(3-0) RB: Electrical and Computer Engineering and Computer Science and Engineering.
Transceiver architecture designs with emphasis on hardware building blocks. Integrated radio frequency designs for various communication standards. Basic building blocks including low noise and power amplifiers, mixers, voltage control oscillators, and frequency synthesizers. Integrated circuit designs of basic building blocks.

813 Advanced VLSI Design
Spring. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Electrical and Computer Engineering. P: ECE 410 SA: EE 813
Advanced topics in digital integrated circuit design. Design specifications: functionality, performance, reliability, manufacturability, testability, cost. Standard cells. Design-rule checking. Circuit extraction, simulation, verification. Team-based design.

814 Embedded Wireless RF Transceivers
Fall of even years. 3(3-0)
Transceiver architecture designs. Software components. Realtime computing and synchronization on digital signal processing platforms, embedded software transceivers, receiver hardware and software considerations, signal structures and CDMA codes, real-time acquisitions and tracking, synchronization, software receivers.

816 Cryptography and Network Security
Fall. 3(3-0)
Major security techniques, including authenticity, confidentiality, message integrity, non-repudiation, and the mechanisms to achieve them. Network security and system security practices, including authentication practice, e-mail security, IP security, Web security, and firewalls.

818 Robotics
Spring. 3(3-0) RB: ECE 313 or ME 451 R: Open only to graduate students in the College of Engineering.
Robot modeling, kinematics, dynamics, trajectory planning, programming, sensors, controller design.

820 Advanced Computer Architecture
Fall, Spring. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Computer Science and Engineering. RB: CSE 410 and CSE 420 R: Open only to Computer Science or Electrical Engineering majors. SA: CPS 820
Instruction set architecture. Pipelining, vector processors, cache memory, high bandwidth memory design, virtual memory, input and output. Benchmarking techniques. New developments related to single CPU systems.

821 Advanced Power Electronics and Applications
Fall. 3(3-0) RB: Power and computer engineering areas.
Power semiconductor devices, circuits, control, and applications. Converter and inverter analysis and design, DSP (Digital Signal Processor) control and implementation. Automotive and utility applications.

823 Power System Stability and Control
Fall of even years. 3(3-0) RB: ECE 826 SA: EE 823
Analysis and simulation of small and large disturbance stability of power systems. Generator, exciter, voltage regulator models. Design of excitation systems and power system stabilizers.

824 Power System Operation and Control
Fall of odd years. 3(3-0) RB: ECE 421 and STT 351 SA: EE 824
Operation planning of power systems including loadflow, unit commitment, production cost methods. On line operation and control including automatic generation control, economic dispatch, security assessment, state estimation.

825 Alternating Current Electrical Machines and Drives
Spring of even years. 3(3-0) RB: ECE 320 SA: EE 825
Analysis, modeling and design of synchronous, induction, and switched reluctance machines. Design drives for motion control and power system applications.

826 Linear Control Systems
Fall. 3(3-0) RB: (MTH 314) SA: EE 826
Vector spaces, representation, system description, solution to the state equations, stability, controllability and observability. Adjoints of linear maps. Eigenstructure assignment. Partial and full order observers. Disturbance decoupling.

831 Analog Circuit Theory
Fall of even years. 3(3-0) SA: EE 831
Positive real functions. Filter approximations. Passive and active network synthesis. Nullor network analysis and synthesis. Active filters. Stability. Sensitivity.

832 Analog Integrated Circuit Design
Fall of odd years. 3(3-0) SA: EE 832
Technology. Device modeling. Circuit simulation. Integrated circuit building blocks. Amplifiers, comparators, converters. Switched-capacitor filters. Analog signal processing circuits.

835 Advanced Electromagnetic Fields and Waves I
Fall. 3(3-0) SA: EE 835
Electrostatics, magnetostatics, electrodynamics and Maxwell's equations. Potential functions. Eigenfunction expansion. Green's functions. Radiation of EM waves. EM boundary-value problems. TEM waves. Maxwell's equations with magnetic sources.

836 Advanced Electromagnetic Fields and Waves II
Fall of odd years. 3(3-0) RB: ECE 835 SA: EE 836
Theory of guided transmission system. Microstrip lines, metallic and dielectric waveguides. EM cavities. Excitation and discontinuities of waveguides. Surface wave and radiation modes. Integrated optics. Scattering of EM waves.

837 Computational Methods in Electromagnetics
Fall of odd years. 3(3-0) P: ECE 835 R: Open to graduate students in the Department of Electrical and Computer Engineering and open to graduate students in the Department of Physics and Astronomy and open to graduate students in the Department of Mathematics.
Numerical methods and linear spaces. Finite difference time domain methods. Yee Algorithm. Boundary truncation methods. Perfectly matched layers. Finite element method (time and frequency). Scalar basis functions. Vector basis functions. Boundary truncation using PMLs. Integral equation methods. Surface and volume integral equations.

848 Evolutionary Computation
Fall of even years. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Computer Science and Engineering. RB: CSE 841 and CSE 440 R: Open to graduate students in the Department of Computer Science and Engineering and open to graduate students in the Department of Electrical and Computer Engineering or approval of department.
Investigation of evolutionary computation from a historical, theoretical and application viewpoint. Readings from the present literature, experiments with provided software on the application of evolutionary computation principles.

850 Electrodynamics of Plasmas
Spring of odd years. 3(3-0) Interdepartmental with Astronomy and Astrophysics and Physics. Administered by Electrical and Computer Engineering. RB: ECE 835 or PHY 488 SA: EE 850
Plasma kinetic and macroscopic plasma transport theory. Electromagnetic wave propagation and charged particle diffusion processes in plasma. Electromagnetic energy absorption via elastic and inelastic collisions. Dc, rf, and microwave discharges.

851 Linear Systems and Control
Fall. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Electrical and Computer Engineering. RB: Undergraduate coverage of linear algebra, differential equations and control/systems
State models and their stability, controllability, and observability properties. Finding minimal realizations of transfer functions. Design of state and output feedback controllers. Design of state observers. LQ regulator and the Kalman filter. Time-varying systems.

853 Optimal Control
Spring of odd years. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Electrical and Computer Engineering.
Static optimization. Nonlinear optimal control of discrete and continuous systems, with specialization to the LQ regulator and tracking. Extending the deterministic results to the Kalman filter and the LQG regulator. Dynamic programming and inequality constraints. Convex optimization and LMI's.

854 Robust Control
Spring of even years. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Mechanical Engineering. R: Open to graduate students in the College of Engineering.
Linear systems and norms for signals and systems. Investigation of stability and performance of control systems. Model reduction, uncertainty, and robustness. Parameterization of stabilizing controllers, Ricatti equations and related factorizations. Application to H-2, H-infinity, and L-1 control.

856 Adaptive Control
Fall of even years. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Electrical and Computer Engineering.
Real-time parameter estimation. Design of self-tuning regulators and model reference adaptive controllers. Investigation of robustness and robust adaptive controllers. Extension to nonlinear systems.

859 Nonlinear Control
Spring. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Electrical and Computer Engineering. RB: ECE 826 and ME 857 SA: ECE 827
Second-order systems. Fundamental properties of solutions. Lyapunov stability. Input-output stability. Passivity. Absolute stability. Linearization. Integral control. Feedback linearization. Sliding mode control. Lyapunov redesign. Passivity-based control. Recursive methods. Applications to electrical and mechanical systems.

859 Nonlinear Systems and Control
Spring. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Mechanical Engineering. RB: ECE 851 R: Open to students in the College of Engineering. SA: ECE 827
Second-order systems and fundamental properties of solutions. Lyapunov stability, input-output stability, passivity, absolute stability, and linearization. Design of feedback controllers using integral control, feedback linearization, sliding mode control, Lyapunov redesign, passivity-based control, and recursive methods. Applications to electrical and mechanical systems.

863 Analysis of Stochastic Systems
Fall. 3(3-0) RB: STT 441 SA: EE 863
Advanced topics in random variable theory. Stochastic processes and stochastic calculus. Optimal systems for filtering and detection.

864 Detection and Estimation Theory
Spring. 3(3-0) RB: ECE 863 SA: EE 864
Analysis and implementation of statistical estimation and detection methods used in signal processing, communications, and control applications. Bayesian, Neyman-Pearson, and minimax detection schemes. Bayesian, mean-square-error, and maximum-likelihood estimation methods.

865 Analog and Digital Communications
Fall of odd years. 3(3-0) RB: ECE 457 and ECE 863 SA: EE 865
Optimum signal design in noisy channels, matched filters, quadrature sampling of band-pass signals in noise. Coherent and non-coherent binary modulation such as PSK, FSK, DPSK, M-ary modulation, intersymbol interference, spread spectrum.

867 Information Theory and Coding
Spring. 3(3-0) P: ECE 863
Shannon information measures. Uniqueness theorem and chain rules of the entropy measures. Kullback-Leibler relative-entropy. The I-measure. Asymptotic Equipartition Property (AEP) for various sources. Channel capacity; discrete-memoryless and symmetric channels. The channel coding theorem. Rate-distortion theory. Applications of coding to modern communications and compression methods such as image

870 Introduction to Micro-Electro-Mechanical Systems
Fall. 3(3-0) RB: ECE 477 and ECE 474
Micro-electro-mechanical systems (MEMS). Fundamentals of micromachining and microfabrication techniques. Design and analysis of devices and systems in mechanical, electrical, fluidic, and thermal energy and signal domains. Sensing and transduction mechanisms, including capacitive and piezoresistive techniques. Design and analysis of miniature sensors and actuators. Examples of existing devices and their applications.

871 Micro-electro-mechanical Systems Fabrication
Spring. 3(3-0) P: ECE 870 or ECE 477
Development of a complete integrated microsystem from inception to final test. Design, fabrication and testing of integrated microsystems. Development of a complete multichip microsystem containing sensors, signal processing, and an output interface. Basic MOS device and circuit processes, wafer bonding and micromachining, low power portable devices and diamond MEMS chips.

874 Physical Electronics
Fall. 3(3-0) SA: EE 874
Applications of quantum mechanics and statistical mechanics in solids. Band theory of semiconductors. Electrical transport phenomena. Pn junctions.

875 Electronic Devices
Spring. 3(3-0) RB: ECE 874 SA: EE 875
Operating properties of semiconductor devices including DC, AC, transient and noise models of FET, BJT, metal-semiconductor contact, heterostructure, microwave and photonic devices.

885 Artificial Neural Networks
Fall. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Electrical and Computer Engineering. SA: EE 885
Overview of neuro-engineering technology. Basic neural network architectures. Feedforward and feedback networks. Temporal modeling. Supervised and unsupervised learning. Implementation. Basic applications to pattern recognition.

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 8 credits. A student may earn a maximum of 24 credits in all enrollments for this course. SA: EE 899
Master's thesis research.

920 Selected Topics in High Performance Computer Systems
Spring of odd years. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. Interdepartmental with Computer Science and Engineering. Administered by Computer Science and Engineering. P: CSE 822 R: Open only to students in the Computer Science and Engineering major or approval of department. SA: CPS 920
Design of high performance computer systems. Seminar format.

921 Advanced Topics in Digital Circuits and Systems
Fall, Spring. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. Interdepartmental with Computer Science and Engineering. Administered by Electrical and Computer Engineering. SA: EE 921
Topics vary each semester.

921B Embedded Architectures
Fall of odd years, Spring of odd years. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Electrical and Computer Engineering. RB: ECE 809 and ECE 813 SA: EE 921B
Embedded computers and architectures for real-time computation and/or robust control. ASICs. Bit-slice architectures. Systolic arrays. Neural networks. Genetic algorithms. Implementation technologies and design issues.

925 Advanced Topics in Power
Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. SA: EE 925
Topics vary each semester.

925C Advanced Machine Drives
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 825 and ECE 829 SA: EE 925C
Nonlinear drives based on state reconstruction and nonlinear and adaptive control. Sensors, implementation, special computer architectures.

929 Advanced Topics in Electromagnetics
Fall, Spring. 3 to 4 credits. A student may earn a maximum of 10 credits in all enrollments for this course. SA: EE 929
Topics vary each semester.

929A Planar Waveguides and Circuits
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 835 SA: EE 929A
Planar open-boundary waveguides and circuits. Surface and microstrip waveguides. Propagation-mode spectrum. Spectral analysis of layered media. Sommerfeld analysis. Integral-operator description of open waveguides and planar circuits.

929B Antenna Theory
Fall of odd years, Spring of odd years. 4(4-0) RB: ECE 835 SA: EE 929B
Antennas and EM scattering. Radiation by currents and surface fields. Equivalence principle. Receiving antennas. Arrays and synthesis. Integral equations. Current and impedance of wire antennas. Slot, aperture and reflector antennas. Singularity expansion method.

929C Geometrical Theory of Diffraction
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 835 SA: EE 929C
Fourier expansion and asymptotic evaluation of two-dimensional electromagnetic fields. Scattering from half-planes, wedges and cylinders. Geometrical optics and ray-tracing. Reflection and transmission matrices. Geometrical diffraction theory.

929D Fast Computational Methods in Electromagnetics and Acoustics
Spring of odd years. 3(3-0) P: ECE 835 R: Open to graduate students in the Department of Electrical and Computer Engineering and open to graduate students in the Department of Physics and Astronomy and open to graduate students in the Department of Mathematics.
Computation-cost and complexity, structured matrices and polynomials. Fourier methods on uniform and non-uniform grids. Fast multipole methods for the Laplace equation. Fast multipole methods for the Helmholtz kernel. Plane wave time domain methods for the retarded potential, rank deficiency and SVD based methods.

931 Advanced Topics in Electronic Devices and Materials
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 12 credits in all enrollments for this course. SA: EE 931
Topics vary each semester.

931A VLSI Technology
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 875 SA: EE 931A
Oxidation, doping techniques, simulation techniques, film deposition and etching, epitaxial growth, lithography, passivation, and packaging.

931B Microdevices and Microstructures
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 875 SA: EE 931B
Technology, modeling and simulation of submicron solid state devices. Microsensors and micromachining. Diamond and superconducting devices. Vacuum microelectronic structures.

931C Properties of Semiconductors
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 874 SA: EE 931C
Carrier scattering, single particle and collective transport, quantum effects, hot electron effects, electron-photon and electron-phonon interactions.

932 Advanced Topics in Analog Circuits
Spring of odd years. 3(3-0)
Variable topics in advanced circuit analysis.

960 Advanced Topics in Control
Fall, Spring. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. RB: ECE 827 and ECE 829 SA: EE 960
Topics vary each semester.

960C Networked and Embedded Control Systems
Spring of odd years. 3(3-0) P: ECE 851
Fundamentals on hardware, software, and networking. Stability and control of hybrid systems. Switched systems. Control with communication constraints. Fundamental limits on bit rate. Multi-agent coordination and control.

963 Advanced Topics in Systems
Fall, Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. SA: EE 963
Topics vary each semester.

966 Advanced Topics in Signal Processing
Fall, Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. SA: EE 966
Topics vary each semester.

966A Discrete Time Processing of Speech Signals
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 466 and ECE 863 and ECE 864 SA: EE 966A
Digital speech models. Short term temporal processing. Linear predictive and spectral analysis. Speech coding and synthesis, recognition, enhancement.

966C Advanced Topics in Statistical Signal Processing
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 466 and ECE 863 and ECE 864 SA: EE 966C
Communication channels, noise models, hypothesis testing of signals by Bayesian minimax, and Neyman-Pearson criteria. Performance evaluation using ROC. Bayesian and maximum likelihood parameter estimation. Kalman-Bucy filtering.

989 Advanced Topics in Plasma
Fall of odd years, Spring of odd years. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. SA: EE 989
Topics vary each semester.

989A Plasma Processing for IC Fabrication
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 835 and ECE 850 SA: EE 989A
Process requirements. Plasma reactors. Etching and deposition applications. Broad ion beam processing.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 72 credits in all enrollments for this course. SA: EE 999
Doctoral dissertation research.