ELECTRICAL AND COMPUTER ENGINEERING   ECE

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 231 or concurrently) or (EGR 102 or concurrently) or (CSE 220 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. 3(3-0) P: (ECE 201) and ((MTH 235 or concurrently) or MTH 340 or MTH 347H) 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. 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. 3(3-0) P: (CSE 231 or concurrently) or (CSE 220 or concurrently) 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 or MTH 254H) and (ECE 201 or concurrently)
Application of linear algebra, 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 R: Open to students in the Electrical Engineering Major and open to students in the Computer Engineering Major. 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 MTH 340 or MTH 347H) 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 305 or concurrently) R: Open to students in the Electrical Engineering Major and open to students in the Computer Engineering Major. 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 220 or CSE 232) and (ECE 230 and (ECE 203 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 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. 3(2-3) P: ((MTH 234 or concurrently) or (MTH 254H or concurrently) or (LB 220 or concurrently)) and ((PHY 184 or PHY 184B or PHY 234B) and completion of Tier I writing requirement) R: Open to juniors or seniors in the College of 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.

377   Principles of Electronic Devices
Fall, Spring. 3(3-0) P: PHY 184 and ECE 202 R: Open to students in the Department of Electrical and Computer Engineering. Not open to students with credit in ECE 474.
Theory and basic principles of the operation of solid state devices. Semiconductor device equations. P-N junction theory developed and applied to the analysis of diodes, bipolar transistors, field effect transistors.

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.

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 to juniors or seniors or graduate students in the Computer Engineering major or in the Electrical 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 to juniors or seniors or graduate students in the Computer Engineering major or in the Electrical Engineering major.
Electromagnetics for electrical systems. Signals and spectra. Regulations. Radiated and conducted emissions. Conducted and radiated immunity. Mitigation techniques.

410   VLSI Design
Spring. 4(3-3) P: ECE 230 and ECE 303 and ECE 377 R: Open to juniors or seniors or graduate students in the College of Engineering. SA: EE 410
Integrated circuit design fundamentals and specifications. Design layout rules, rule checking. Circuit extraction, simulation, verification. Team-based design.

ECE—Electrical and Computer Engineering

411 Electronic Design Automation
Fall. 4(3-3) P: CSE 320 or ECE 331 R: Open to juniors or seniors or graduate students in the College of 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 to students in the Department of Electrical and Computer Engineering. 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 to juniors or seniors in the Computer Engineering major or in the Electrical 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.

417 Robotics
Spring. 4(3-3) P: ECE 313 or ME 451 R: Open to undergraduate students or graduate students in the Department of Electrical and Computer Engineering.
Robot modeling, kinematics, dynamics, planning, trajectory generation, and control.

420 Machines and Power Laboratory
Fall. 1(3-0) P: (ECE 320 or concurrently) or (ECE 423 or concurrently) R: Open to juniors or seniors in the College of 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 to students in the Department of Electrical and Computer Engineering and open to students in the Department of Computer Science and 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.

424 Electrical Drives
Fall. 3(3-0) P: ECE 313 and ECE 320 R: Open to juniors or seniors in the College of Engineering.
Modeling AC motors. Reference frame theory for control of AC motors. Vector control. Pulse width modulation inverter. Sensorless control.

425 Solid State Power Conversion
Fall. 3(3-0) A student may earn a maximum of 3 credits in all enrollments for this course. P: ECE 320 and ECE 313 and (ECE 420 or concurrently) R: Open to undergraduate students in the Department of Electrical and Computer Engineering.
Power converter topologies: DC/DC converters, DC/AC inverters, AC/DC rectifiers, AC/AC converters. Semiconductor switching devices. Modeling and control of power converters: steady-state analysis, state space averaging, small-signal model, closed-loop control, simulation. Application of power converters in motor drives and renewable power generation.

430 Embedded Cyber-Physical Systems
Fall. 4(3-3) P: ECE 331 R: Open to students in the Department of Electrical and Computer Engineering.
Modeling continuous and discrete dynamics of embedded cyber-physical systems (CPS). Hybrid systems. Composition of state machines. Concurrent models of computation.

431 Smart Sensor Systems
Spring of odd years. 3(2-3) P: ECE 303 and ECE 331 R: Open to students in the Department of Electrical and Computer Engineering.
Architecture and design of microcontroller-based embedded smart sensor systems. Theory and techniques of instrumentation and smart system implementation.

434 Autonomous Vehicles
Fall. 3(2-2) Interdepartmental with Computer Science and Engineering. Administered by Electrical and Computer Engineering. P: ECE 331 or CSE 331 RB: Proficiency in Python programming strongly recommended, equivalent to a one-semester Python class. R: Open to juniors or seniors in the College of Engineering.
Overview of technologies vehicles including sensors, sensing algorithms, machine learning, localization, mapping, object detection, tracking, communication and security. Hands-on implementation of robotic sensing and navigation algorithms on both simulated and physical mobile platforms.

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 Department of Electrical and Computer Engineering.
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. 3(3-0) P: PHY 184 R: Open to juniors or seniors in the College of Engineering.
Principles of biophysics and electrophysiology, ionic basis of neuronal excitability, introduction to computational models of signal generation and propagation in the nervous system, applications to neural systems and neuroprosthetics.

449 Fundamentals of Acoustics
Fall. 3(3-0) P: (MTH 235 and ECE 280) or ME 391 R: Open to juniors or seniors in the College of Engineering.
Development of the fundamental theoretical concepts of acoustical systems, including plane and spherical waves, radiation, diffraction, and absorption.

456 Introduction to Communication and Network Security
Spring. 3(3-0) P: ECE 280 or STT 351 R: Open to juniors or seniors in the College of Engineering.
Security primitives, major network security protocols and applications, system security practices, wireless security physical-layer built-in security, secure multiple-party computing, privacy-preserving computation.

457 Communication Systems
Spring. 3(3-0) P: ECE 302 and ECE 366 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 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
Spring. 3(3-0) P: ECE 366 R: Open to seniors or graduate students in the College of Engineering. SA: EE 466

Discrete Fourier transforms, sampling theorem, circular convolution, Z-transforms. Design of finite impulse response filters. Applications of digital signal processing to multidimensional signals and machine learning.

476   Electro-Optics
Fall, Summer. 4(3-3) P: ECE 302 and ECE 303 and ECE 305 R: Open to juniors or seniors or graduate students in the Computer Engineering major or in the Electrical 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 303 and ECE 377 R: Open to juniors or seniors in the College of 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 325 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.

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.

489   Independent Senior Design
Fall, Spring, Summer. 4(4-0) P: {(((ECE 303 and ECE 313 and ECE 320 and ECE 331 and ECE 366 and (ECE 390 or concurrently)) or approval of department) and completion of Tier I writing requirement) or (CSE 410 or approval of department)} and (ECE 390 or concurrently or approval of department) R: Open to seniors in the Department of Electrical and Computer Engineering.

Individual design project with software and hardware components.

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 to students in the College of 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.

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.

816   Cryptography and Network Security
Spring of even years. 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.

817   Advanced Electrical Drives
Fall. 3(3-0) RB: ECE 313 and ECE 320 Not open to students with credit in ECE 424.

Modeling and control of AC motors

818   Robotics
Spring. 3(3-0) RB: ECE 313 or ME 451 R: Open to graduate students in the College of Engineering. Not open to students with credit in ECE 417.

Robot modeling, kinematics, dynamics, trajectory planning, sensors, controller design, motion planning.

819   Smart Material Sensors and Actuators
Fall of odd years. 3(3-0) RB: General background in mechanics, dynamics, and control systems at the undergraduate level is desirable although not required.

Fundamentals of piezoelectric materials, magnetostrictive materials, shape memory alloys, electroactive polymers, and other emerging smart materials. Sensing and actuation mechanisms. Physics-based, control-oriented modeling of transducer dynamics. Modeling and control of hysteresis. Device and system applications in sensing, actuation, and energy harvesting.

820   Advanced Computer Architecture
Fall of even years. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Computer Science and Engineering. RB: CSE 325 and CSE 420 R: Open to graduate students in the Department of Computer Science and Engineering or in the Department of Electrical and Computer Engineering. SA: CPS 820

Advanced concepts in the organization and architecture of modern computer systems.

821   Advanced Power Electronics and Applications
Fall. 3(3-0) RB: Power and computer engineering areas. Not open to students with credit in ECE 425.

Power semiconductor devices, circuits, control, and applications. Converter and inverter analysis and design, DSP (Digital Signal Processor) control and implementation. Automotive and utility applications.

822   Power System Analysis
Spring. 3(3-0) P: ECE 320 or concurrently R: Open to graduate students in the Department of Electrical and Computer Engineering. Not open to students with credit in ECE 423.

Synchronous machines. Models and measurements of power components. Symmetrical components.

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 Reliability
Fall of odd years. 3(3-0) RB: STT 441

Fundamentals of stochastic processes. Modeling of components and systems for reliability analysis of engineering systems.

825   Alternating Current Electrical Machines and Drives
Spring of even years. 3(3-0) P: ECE 817 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.

827   Power Electronic Systems for Renewable Energy, Transportation, and Utility Applications
Spring of odd years. 3(3-0) P: ECE 821 SA: ECE 924

Converter/inverter system analysis, control, and design. Renewable energy power conversion systems. Power/energy conversion systems for hybrid and electric vehicles. FACTS (flexible ac transmission system) devices for utility applications.

ECE—Electrical and Computer Engineering

830 Embedded Cyber-Physical Systems
Fall. 3(3-0) RB: Undergraduate degree in Electrical Engineering, Computer Engineering, or related major. R: Open to students in the Department of Electrical and Computer Engineering. Not open to students with credit in ECE 430.
Modeling continuous and discrete dynamics of embedded cyber-physical systems (CPS). Hybrid systems. Composition of state machines. Concurrent models of computation. Design and implementation of CPS including sensors and actuators, embedded processors, Internet of Things (IoT), cloud IoT, multitasking, and scheduling. Analysis and verification of CPS. Emerging topics in CPS.

832 Analog Integrated Circuit Design
Spring of even 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
Spring of even 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
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.
Numerical methods and linear spaces. Finite difference time domain methods. Yee Algorithm. Boundary truncation methods. Perfectly matched layers (PMLs). Finite element method (time and frequency). Scalar basis functions. Vector basis functions. Boundary truncation using PMLs. Integral equation methods. Surface and volume integral equations.

842 Performance Modeling of Communication Networks
Fall. 3(3-0) RB: ECE 280 or STT 351 R: Open to students in the Department of Electrical and Computer Engineering. Not open to students with credit in ECE 442.
Fundamental theories and protocols for communication networks, with an emphasis on statistical performance modeling of Medium Access Control, Data Link Control, Routing, and Transport Layer Protocols. Simulation based and application-driven class projects.

846 Multi-Criterion Optimization and Decision-Making
Fall of even years. 3(3-0) RB: Knowledge on at least one programming language; basic knowledge in Calculus.
Definitions for Pareto-optimality and systematic computerized algorithms for finding Pareto-optimal solutions. Classical generative and emerging methods using evolutionary optimization methods. Decision-making tasks to choose a final preferred solution.

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 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.

866 Time-Frequency and Wavelet Analysis
Spring of even years. 3(3-0) RB: ECE 466
Basis functions. Orthonormal Signal Expansion. Short-Time Fourier Transform (STFT). Gabor Decomposition. Wigner Distribution. Cohen's Class of Time-Frequency Distributions. Multiresolution Analysis. Discrete Wavelet Transform (DWT). Quadrature Mirror Filters (QMF). Biorthogonal Wavelets. Two-Dimensional Wavelets. Wavelet Packets. Overcomplete dictionaries and sparse representations. Applications in signal and image denoising and compression.

867 Information Theory and Coding
Fall of odd years. 3(3-0)
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

869 Wireless Communications and Networking
Fall of even years. 3(3-0) RB: ECE 457
Cellular system design, characterization of wireless channels, signaling and receiver design for mobile radio, multiple access techniques and mobility management.

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 mechanic 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.

877 Cleanroom Procedures
Fall. 3(2-3) R: Open to graduate students in the College of Engineering.
Cleanroom procedures and safety. Instrumentation for microfabrication processes and device measurements. Fabrication and testing of devices.

884 Neural Networks and Deep Learning
Fall. 3(3-0)
Fundamental understanding and advanced concepts in neural networks and deep-learning.

885 Artificial Neural Networks
Spring. 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. R: Open to students in the Computer Science Major or approval of department. SA: CPS 920
Design of high performance computer systems. Seminar format.

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.

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.

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.

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.

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.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 36 credits in all enrollments for this course. SA: EE 999
Doctoral dissertation research.