985. Counseling Pre-Practicum Spring. 3(2-1) Doctoral status in college counseling or related area and approval of department. Supervised experience working with college students in areas related to counseling. Group discussion, group supervision and observation of counseling interviews, and individual supervision.

986A. Counseling Practicum I Fall. 3(0-3) 985 or approval of department. Supervised experience working with college students in a counseling relationship. Group discussion, group supervision, and observation of counseling interviews, and individual supervision.

986B. Counseling Practicum II Winter. 3(0-3) 986A. Supervised experience working with college students in a counseling relationship. Group discussion, group supervision, and observation of counseling interviews, and individual supervision.

986C. Counseling Practicum III Spring. 3(0-3) 986B. Supervised experience working with college students in a counseling relationship. Group discussion, group supervision, and observation of counseling interviews, and individual supervision.

987A. Seminar: Continuing Education and Social Policy Fall. 3(0-3) May re-enroll for a maximum of 6 credits. Major or approval of department. Continuing education, as social force impacting and impacted by government and corporate policy. Examination of domestic and foreign examples of interaction between social policy and continuing education.

987B. Seminar: Continuing Education in Higher Education Institutions Winter 3(0-3) May re-enroll for a maximum of 6 credits. Major or approval of department. Patterns, problems, and potential for continuing education in two and four year colleges. Problems of governance, reward system, leadership roles, etc.

988. Behavioral Counseling Laboratory Fall, Winter, Spring. 1 to 6 credits. May re-enroll for a maximum of 21 credits. Supervised experience in behavioral counseling (individual and group), community consultation, applied behavioral research, journal manuscript preparation, preparing instructional materials, and instructional management.

990A. Field Experience: Special Education Administration Simulation Spring. 3(0-9) Approval of department. Supervised graduate practicum in administration of the Special Education program of a simulated school district.

990B. Field Experience: Special Education Administration Fall, Winter, Spring, Summer. 3 to 12 credits. May re-enroll for a maximum of 18 credits. Approval of department. Supervised graduate practicum or internship in special education administration.

990C. Field Experience: Special Education Spring. 3 to 12 credits. May re-enroll for a maximum of 18 credits. Approval of department. Supervised graduate practicum in special education teacher training.

999. Research Fall, Winter, Spring, Summer. Variable credit. Approval of department.

ELECTRICAL ENGINEERING AND SYSTEMS SCIENCE

College of Engineering

Electrical Engineering EE

275. Consumer Electronics Fall, Winter, Spring. 3(3-0)
Electronic circuit components and devices; their operation in transmitters, receivers, stereo-amplifiers, etc. Electronic measurements, magnetic recording, speaker systems, and other topics will be considered.


306. Electromagnetic Fields and Waves II Winter, Spring. 3(3-0) 305. Magnetoostatic fields; EM sources, vector potential, magnetic media, inductance, and energy storage. Time-varying fields and Maxwell's equations; energy conservation, potential theory, and radiation concepts.


308. Fields and Waves Laboratory Spring, Summer. 1(0-3) 306; 307 concurrently. Experiments with charged particle motion in EM fields, dielectric and magnetic properties and materials, probing of currents and charges, and propagation of transient and steady-state waves. Digital computer solutions for EM field and wave problems.

345. Introduction to Electronic Instrumentation Systems Fall, Winter. 4(3-3) PHY 388. Basic electronic concepts; passive and active components; operational amplifiers; switching devices, equivalent circuits; transducers; signal conditioning; recording; data management; basic elements of control.

415. Control Systems Winter. 3(3-0) SYS 313. Formulation of automatic control problems; review of modeling methods; specifications, controllability and stability; controller design via root locus and state-vector methods; survey of digital control.


419. Physical Phenomena and Electronic Instrumentation I Winter. 4(3-3) PHY 200 or 201B; MTH 215. Interdepartmental with and administered by the Physics Department. Concepts of electronics relative to uses in investigations of physical phenomena and their subsequent applications to provide reliable instrumentation. Nuclear radiation detectors, photometers and magnetometers are examples of specific topics covered.

430. Digital Electronics I Fall. 3(3-0) 302. Characteristics and applications of digital integrated circuits. Number systems and Boolean algebra. Gates, flip-flops, clocks, counters, shift registers, A/D and D/A converters. Basic applications of these devices.

431. Digital Electronics II Winter. 3(3-0) 400 or CPS 421. Basics of minicomputer and microcomputer based systems. Programming fundamentals. The I/O bus, interfacing, data acquisition, data storage, and data communication. Practical design problems.
433. Digital Electronics Laboratory
Winter, Spring. 1(0-3) 431 or concurrently. Design, construct and test representative digital electronic circuits. Hands-on experience with minicomputers, microcomputers and programmable calculators. Applications in data acquisition and control.

435. Guided Transmission Systems
Fall. 3(0-3) 308. Electric circuit theory from EM field theory. Guided wave theory: normal modes, propagation characteristics and power transport, wave impedances, traveling and standing waves, rectangular and circular waveguides. Electro-magnetic resonators; frequency and Q.

436. Microwave Networks and Antennas
Winter. 3(0-3) 435; 438 concurrently. Circuit theory for wave-guiding systems: impedance description of microwave one and N-port networks, scattering matrix, excitation and coupling. Radiation and scattering; radiation fields, fields and impedances of cylindrical antennas and arrays, microwave antennas.

438. Transmission and Radiation Laboratory
Winter. 1(0-3) 435; 436 concurrently. Microwave transmission and radiation laboratory. Measurement of frequency, wavelength, standing waves, impedances, and power. Experiments on transmission lines, waveguides, cavity resonators, microwave circuits, and circuit and radiation properties of antennas.

439. Microwave Electronics and Plasma Laboratory
Spring. 1(0-3) 438. Experimental investigations on topics from 437. Laboratory experiments on klystron characteristics, traveling wave amplifiers, microwave semiconductor oscillators, plasma measurements, and plasma-field interactions.

455. Deterministic Communication Systems
Fall. 3(3-0) Approval of department. Communication systems. Representation of signals in time and frequency domain. Processing of signals by filters, single nonlinear and time-variant systems. Linear and nonlinear, analog and digital modulation and demodulation; for example, AM, FM, PCM.

456. Applied Probability in Communication Theory
Winter. 3(3-0) 455 or approval of department. Probability theory as applied in the study of communication systems. Representation of random signals and noise as stochastic processes. Autocorrelation and spectral density.

457. Introduction to Statistical Communication Theory
Spring. 3(3-0) 456; 457 concurrently. Representation, processing and filtering of random signals. Performance of analog, linear and nonlinear modulation systems with noise. Optimum digital communication systems.

464. Control Systems Laboratory
Fall. 2(1-2) SYS 313. Interdepartmental with Systems Science. Experimental investigations of feedback systems. Study of solid state controllers. Properties and applications of phase lock loops. Introduction to digital control.

465. Control System Laboratory
Winter. 1(0-3) 415. Experiments in control of processes with a digital controller. Simulation of control systems.

467. Communication Theory Laboratory
Spring. 1(0-3) 456; 457 concurrently. Experimental investigations on communication theory and information transmission topics from 453, 456, and 457.

474. Physical Properties of Electronic Devices I
Fall. 3(0-3) Energy levels in atoms and crystals. Destiny of states and elementary particle statistics. Transport properties of bulk materials. PN junction diodes and bipolar junction transistor—low and high frequency.

475. Physical Properties of Electronic Devices II
Winter. 3(0-3) 474. Continuation of 474. Physics, models, and elementary applications of a variety of solid-state devices. Field-effect transistors, SCR's, diodes, varactors, and high-frequency and optical devices.

476. Physical Properties of Electronic Devices III
Spring. 3(3-0) 307 and 475. Continuation of 475. Klystrons, space-charge and traveling waves, solid-state microwave devices, parametric amplification, and lasers.

480. Integrated Circuits: Operational Amplifiers
Spring. 3(3-0) 302. Integrated circuits: design principles and fabrication. Differential-amplifier stage signal characteristics. Properties and modes of operational amplifiers. Applications: signal conditioners, signal processors, signal generators, and special-purpose circuits.

484. Electronic Devices Laboratory I

490. Special Topics in Electrical Engineering
Fall, Winter, Spring, Summer. 1 to 4 credits. May re-enroll for a maximum of 12 credits. Approval of department. Exploration of special topics in electrical engineering.

495. Independent Study
Fall, Winter, Spring, Summer. 1 to 3 credits. May re-enroll for a maximum of 3 credits in EE 495 and SYS 495 combined. Approval of department. Independent study of a topic in electrical engineering of particular interest of the student.

499. Undergraduate Research
Fall, Winter, Spring, Summer. 1 to 3 credits. May re-enroll for a maximum of 6 credits in EE 499 and SYS 499 combined. Approval of department. Independent undergraduate research in contemporary areas of electrical engineering such as: alternative energy, monitoring and control, bio-engineering, power systems, integrated electronics, electromagnetic systems.

801. Special Problems
Fall, Winter, Spring, Summer. 1 to 4 credits. Approval of department. Investigation of a topic in electrical engineering compatible with the student's prerequisites, interest, and ability.

811. Noise and Fluctuation Phenomena
Spring of even-numbered years; Summer of odd-numbered years. 3(3-0) Approval of department. Nyquist formulation of thermal noise; noise phenomena associated with electron tubes, transistors, beam and parametric devices, amplifiers, mixers, and detectors; techniques and equipment for noise measurements.

813. Foundations of Network Synthesis
Fall. 3(3-0) Approval of department. One-port networks; RL, RC, LC and RLC networks; driving point inimittances; positive real properties; realization procedures.

832. Filter Synthesis I
Winter. 3(3-0) 831. Two-port LC networks; transmission characteristics; filter design techniques based upon image parameters; Cauer filters.

833. Filter Synthesis II
Spring. 3(3-0) 832. Scattering parameters; Butterworth, Chebyshev and elliptic filters, phase equalizers synthesis based on insertion functions.

834. Electromagnetic Theory I
Fall. 3(3-0) Approval of department. Electrostatics, magnetostatics, electrodynamics, Maxwell's equations, force and energy equations, potential functions, Green's function, radiation of electromagnetic wave, plane waves, cylindrical waves, spherical waves.

836. Electromagnetic Theory II
Winter. 3(3-0) 835. Formulation of electric-circuit theory from viewpoint of electromagnetic theory; calculation of impedances; propagation of electromagnetic wave in isotropic and anisotropic media; skin effects; boundary value problems.

837. Guided Transmission Systems
Spring. 3(3-0) 835. Electromagnetic fields in open-wire lines, coaxial lines and wave guides; power and energy relationships; orthogonal properties; normal modes, resonant cavities, modes of propagation in stratified media; microwave circuits.

846. Analysis of Random Time Functions
Fall, Winter. 3(3-0) Mathematical models for time-dependent random phenomena; properties of correlation functions and spectral densities; stationarity and ergodicity; response of linear systems to random inputs; introduction to applied harmonic analysis.

847. Communication Systems
Winter, Spring. 3(3-0) 846. Comparative analysis of modulation systems; optimal relation between bandwidth and signal-to-noise ratio; telemetry and radar systems.
849. Microwave Electronics  
Winter. 3(3-0) 835.  
Principles of microwave generators, including klystrons, magnetrons, traveling-wave tubes and particle accelerator non-linear electron-wave interactions; crossed-field devices; solid state microwave electronics.

850. Ionized Gases  
Spring. 3(3-0) 855 or PHY 445.  
Interdepartmental with the departments of Astronomy and Astrophysics and Physics.  
Elastic collision processes; Boltzmann equation; moment equations; basic plasma phenomena; motion of a charged particle in electrical and magnetic field; individual and collective charged particle behavior.

851. Bioelectric Field Theory  
Spring. 3(3-0) 399.  
Volume conductor fields; quasistatic formulation, bioelectric sources, boundary conditions; field of a single cell, subthreshold neuron phenomena; integral equations for hippocampal.  
Electrocardiography; bioelectric sources in heart, dipole hypothesis, forward and inverse problems.

874. Physical Electronics  
Fall. 4(4-0) Approval of department.  

875. Solid-State Devices and Circuits  
Winter. 3(3-0) 874.  
Formulation of operating properties and appropriate models of two-terminal and multi-terminal devices formed with semiconductors and solid-state materials. Basic applications.

880. Signal Analysis  
Fall. 3(3-0) Approval of department.  

890. Research  
(EGR 899.) Fall, Winter, Spring, Summer. Variable credit. Approval of department.

911. General Automata Theory I  
Fall of odd-numbered years. 3(3-0)  
CPS 423 or SYS 827 or approval of department. Interdepartmental with and administered by the Computer Science Department.  
Characterization of machines and programs as automata; mathematical decomposition of finite automata.

912. General Automata Theory II  
Winter of even-numbered years. 3(3-0)  
Interdepartmental with and administered by the Computer Science Department.  

913. General Automata Theory III  
Spring of even-numbered years. 3(3-0)  
Interdepartmental with and administered by the Computer Science Department. Degrees of difficulty of computation. Models of parallel computation. Iterative automata.

926. Antenna Theory I  
Winter of even-numbered years. 3(3-0)  
Linear antennas; cylindrical dipole antennas as radiating, receiving and scattering elements; current and charge distributions on antennas; electromagnetic fields of antennas; coupled antennas, linear antenna arrays.

927. Antenna Theory II  
Spring of even-numbered years. 3(3-0)  
Microwave antennas; slot antennas; slot wave guide arrays; horn and reflector-type antennas; frequency independent antennas; pattern theory.

928. Microwave Laboratory  
Summer of even-numbered years. 3(2-3) 837, 927, 989.  
Experiments on transmission line systems; scattering measurements; antenna measurements; interaction of electromagnetic waves with plasmas; radiation in plasmas; experiments on electron tubes and on lasers.

956. Microelectronics II  
Winter of even-numbered years. 3(3-0)  
Miniaturized components; thin-film networks; solid-state circuits and operational limitations.

975. Quantum Electromagnetics  
Winter of odd-numbered years. 3(3-0) 874.  
Tensors; four-vector formulation of classical electrodynamics; relativistic electrodynamics; Lagrangian and Hamiltonian-classical and relativistic; Schrodinger's equation—classical and relativistic; quantization of wave fields, hydrogen atoms.

976. Lasers and Masers  
Spring of odd-numbered years. 3(3-0) 975.  
Coherence, emission, absorption and amplification of radiation; energy levels for optically active materials; threshold, band width, excitation modes and other operating characteristics; applications and recent developments.

989. Waves and Radiances in Plasmas  
Fall of even-numbered years. 3(3-0)  
Interdepartmental with the departments of Astronomy and Astrophysics and Physics. Plasma oscillation; interaction, electromagnetic fields with plasmas, wave propagation in magnetoionic mode, plasma sheet; radiation of electric source in incompressive and compressive plasmas; electroacoustic waves; magnetohydrodynamics; research topics in plasmas.

999. Research  
(EGR 999.) Fall, Winter, Spring, Summer. Variable credit. Approval of department.

311. Introduction to Discrete Systems  
Fall, Winter. 3(3-0) MTH 215.  
Properties of linear discrete-time systems; z-transformation; discrete system transfer functions.

312. Response of Discrete and Continuous Linear Systems  
Winter, Spring. 3(3-0) 311.  

313. Analysis of Control Systems  
Spring, Summer. 3(3-0) 312.  
Mathematical models of physical systems; basic control actions; transient response; error analysis; root locus method; Bode plot techniques.

404. Biological and Ecological Concepts for Engineers and Mathematicians  
Winter. 3(3-0)  
Approval of department. Interdepartmental with and administered by the Zoology Department. Biological and ecological concepts important to formal analysis of living systems, vital properties, processes, and limitations; population dynamics, selection, competition, and predation; ecological community structure and function; industrialized ecosystem.

410. Systems Methodology  
Winter. 3(3-0) IDC 201, MTH 113, CPS 110 or 120. Interdepartmental with the Engineering Department. The systems approach in multidisciplinary large scale problem solving. The development of useful systems analysis tools; systems design; feasibility study; computer simulation for feasibility evaluation.

411. Systems Project  
Spring. 3(3-0) 410. Interdepartmental with the Engineering Department. Completion of a systems study initiated in 410. The project may involve the design of hardware, simulation of a solution to an interdisciplinary problem, or development of a solution concept.

442. Systems Concepts for Biologists  
Winter. 3(3-0) Approval of department.  
Basic concepts of systems science important to formal analysis and control of biological communities, with emphasis on modeling and on analysis of behavior through numerical solutions.

464. Control Systems Laboratory  
Fall. 2(1-3) 313. Interdepartmental with and administered by Electrical Engineering.  
Experimental investigations of feedback systems. Study of solid state controllers. Properties and applications of phase lock loops. Introduction to digital control.

465. Process Optimization Methods  
Fall, Spring. 3(3-0) MTH 215, knowledge of linear algebra. Interdepartmental with and administered by the Chemical Engineering Department. Methods for determining optimum design and operating policies of systems of varying complexity. Includes classical methods, mathematical programming and modern methods.