ELECTRICAL ENGINEERING AND SYSTEMS SCIENCE*

College of Engineering

Electrical Engineering E E

305. *Electromagnetic Fields and Waves I*
Fall, Winter. 3(3-0) MTH 215, PHY 288.
Vector analysis. Electrostatic fields: EM sources, scalar potential, Poisson's and Laplace's equations, dielectric media, capacitance, and energy storage. Boundary value problems for electrostatic fields.

306. *Electromagnetic Fields and Waves II*
Winter, Spring. 3(3-0) 305.
Magnetostatic 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.

307. *Electromagnetic Fields and Waves III*
Spring, Summer. 3(3-0) 306; 308 concurrently.
Application of Maxwell's equations: radiation, propagation, reflection, and power flow of plane EM waves; EM boundary value problems. Transmission line theory: transient and steady state waves, standing and traveling waves, reflections and standing-wave-ratio.

308. *Fields and Waves Laboratory*
Spring, Summer. 1(0-3) 306; 307 concurrently.
Experimental investigation of: 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.

311. *Fundamentals of System Modeling*
Fall, Winter. 3(3-0) MTH 334; PHY 288.
System measurements, signal representations, mathematical models for systems of lumped physical components, topological equations for electrical networks; linear graph theory and its application to modeling electrical, mechanical, hydraulic, and other systems.

312. *Analysis of Linear Systems*
Winter, Spring. 3(3-0) 311.
State Models for general systems; numerical and analytical solutions.

313. *Analysis of Large Scale Systems*
Spring, Summer. 3(3-0) 312.
Stability, pulse and frequency response characteristics, analysis by Laplace and Z transforms, subassemblies of multi-terminal components.

321. *Analog and Digital Computation Laboratory*
Fall, Winter. 1(0-3) MTH 334, PHY 288; 311 concurrently.
Numerical solution of electrical systems problems, component modeling by digital computer, analog computer simulation.

345. *Instrumentation and Computation Laboratory*
Fall, Winter, Spring. 4(3-3) PHY 288.
Signal measuring and generating devices; accuracy and error considerations in laboratory measurements; terminal characteristics of components from measurements; use of analog computers.

374. *Electronics I*
Fall, Winter. 4(4-0) PHY 288.
Current, voltage and power. DC, AC and transient RLC circuit analysis. Resonance phenomena; bridges; nonlinear circuitry. Two-port networks and their equivalent circuits. Computer-aided analysis and design of circuits.

375. *Electronics II*
Winter, Spring. 4(4-0) 374.
Volt-ampere characteristics of the transistor. Voltage, current and power amplification. Stability and transient effects. Oscillators, operational amplifiers.

376. *Electronics III*
Spring, Summer. 3(3-0) 375.
Boolean algebra and logic circuits. Design, analysis, and evaluation of monostable, astable and bistable multi-vibrator circuits, logic circuits and systems. Aspects of reliability.

384. *Electronics Laboratory I*
Fall, Winter. 1(0-3) 374 concurrently.
Experimental and measurement procedures, as appropriate to topics covered in 374.

386. *Electronics Laboratory II*
Spring, Summer. 1(0-3) 376 concurrently.
Experimental investigation of topics covered in 375 and 376. Computer-aided analysis and design of electronic circuits.

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

415. *Control Systems*
Fall. 3(3-0) 313 or M E 455, MTH 334.
Formulation of automatic control problems; review of modeling method; specifications, controllability and stability; controller design via root locus and state-vector methods; survey of digital control.

416. *Control System Design*
Winter. 3(3-0) 415.
Realization of linear controllers, consistent models for plant and computer sampling, algorithms for digital control, organization of digital controllers.

418. *Introduction to Network Synthesis*
Spring. 3(3-0) 313.
Overview: specification, approximation, synthesis. Physical realizability of passive two-element kind one-port and two-port functions. Foster and Cauer one-port syntheses. Lattice, ladder and cascade two-port syntheses. Selected active network synthesis.

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

436. *Microwave Networks and Antennas*
Winter. 3(3-0) 435; 438 concurrenly.
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 impedance of cylindrical antennas and arrays, microwave antennas.

437. *Microwave Electronics and Plasma*
Spring. 3(3-0) 436; 439 concurrently.
Electron dynamics; field-particle interactions; space-charge waves; cyclotron waves; klystron; magnetron; traveling-wave amplifier; quadrupole amplifiers; microwave solid-state devices; gas discharges; plasma; waves in plasma.

438. *Transmission and Radiation Laboratory*
Winter. 1(0-3) 435; 436 concurrently.
Microwave transmission and radiation laboratory. Measurement of frequency, wavelength, standing waves, impedance, 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; 437 concurrently.
Experimental investigations on topics from 437. Laboratory experiments on klystron characteristics, traveling wave amplifier, microwave semiconductor oscillator, plasma measurements, and plasma-field interactions.

455. *Deterministic Communication Systems*
Fall. 3(3-0) 374 or approval of department.
Communication systems. Representation of signals in time and frequency domain. Processing of signals by linear, simple 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; 467 concurrently.
Representation, processing and filtering of random signals. Performance of analog, linear and nonlinear modulation systems with noise. Optimal digital communication systems.

460. *Introduction to Electromagnetics*
Spring. 3(3-0) PHY 288.
Electric and magnetic fields; boundary conditions; Maxwell's equations. Electromagnetic waves. Wave guides and cavities. Charged particles in an electromagnetic field.

466. *Control Systems Laboratory*
Winter. 1(0-3) 415; 416 concurrently.
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 455, 456, and 457.

*Effective March 1, 1969.

474. Physical Properties of Electronic Devices I

Fall. 3(3-0) 376.

Energy levels in atoms and single crystals. Density of states and elementary statistics. Transport phenomena in semiconductors. Junctions. Computer-aided analysis of transport phenomena in semiconductors.

475. Physical Properties of Electronic Devices II

Winter. 3(3-0) 474.

Bulk semiconductors effects and devices. Single-junction and multiple-junction devices. Sources of optical radiation, including lasers. Methods of detecting optical radiation. Solar cells. Thermal and electromechanical effects and devices.

476. Physical Properties of Electronic Devices III

Spring. 3(3-0) 475.

Continuation of topics covered in 475. Aspects of integrated-circuit techniques.

484. Electronic Devices Laboratory I

Fall. 1(0-3) 474 concurrently.

Introduction to materials handling and preparation techniques. Fabrication of electronic devices. Measurement of bulk properties of materials. Compuer-aided analysis of transport phenomena in semiconductors.

485. Electronic Devices Laboratory II

Winter. 1(0-3) 475 concurrently.

Materials preparation techniques. Fabrication of electronic devices. Measurement of bulk properties of materials. Computer-aided analysis of semiconductor devices.

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.

816. Quantum Electronics

Fall. 3(3-0) Approval of department.

Quantized wave motion; Hamiltonian function and operator; hydrogen atom and energy states; transition probabilities; spontaneous and induced transitions; statistical physics; transport phenomena; band theory applied to conductors, semi-conductors and insulators.

818. Electrical Properties of Materials I

Winter of odd-numbered years. 3(3-0) 816.

Study of atomic and molecular properties affecting the conductivity, permittivity, permeability, absorptivity and radioactivity of materials, classical and quantum considerations.

819. Electrical Properties of Materials II

Spring of odd-numbered years. 3(3-0) 818.

Temperature and frequency effects on conduction, dielectric constant, and dielectric loss; temperature, frequency and bias effects on the behavior of ferrite materials; stimulated emission and absorption in materials.

831. Foundations of Network Synthesis

Fall. 3(3-0) Approval of department.

One-port networks; RL, RC, LC and RLC networks; driving point immitances; positive real properties; realization procedures.

832. Filter Synthesis I

Winter. 3(3-0) 831.

Two-port LC networks; transmission characteristics; filter design techniques based on 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.

835. Electromagnetic Theory I

Fall. 3(3-0) Approval of department.

Physical concepts and mathematical solution of Maxwell equations; boundary conditions; force and energy equations; potential equations; Green's function; wave equations; radiation and propagation of electromagnetic waves.

836. Electromagnetic Theory II

Winter. 3(3-0) 835.

Formulation of electric-circuit theory from viewpoint of electromagnetic theory; caluciation of impedance; 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; orthogonality properties; normal modes; resonant cavities; modes of propagation in stratified media; microwave circuits.

845. Mathematical Models for Random Phenomena

Fall, Summer. 3(3-0) Approval of department.

Generation of mathematical models that employ probabilistic notions to describe control, communication, and related systems, with emphasis on distributions of random variables, conditioning, and properties of random sequences.

846. Analysis of Random Time Functions

Fall, Winter. 3(3-0) 845.

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.

848. Physical Electronics

Fall. 3(3-0) Approval of department.

Types of electron emission; electron motion in electromagnetic fields; beam focusing; longitudinal and transverse beam waves; concepts of interaction between electrons and fields; basic principle of parametric electronics.

849. Microwave Electronics

Winter. 3(3-0) 835, 848.

Principles of microwave generators, including klystrons, magnetrons, traveling-wave tubes and particle accelerators; non-linear electron-wave interactions; crossed-field devices; solid state microwave electronics.

850. Ionized Gases

Spring. 3(3-0) 835 or PHY 448. Interdepartmental with the Astronomy Department.

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.

852. Semiconductor Devices

Winter. 3(3-0) 816.

Applications of the diffusion and continuity equations to semiconductor devices; delineation of the device terminal properties including transient operation.

853. Semiconductor Applications

Spring. 3(3-0) 852.

Equivalent circuits; analysis of circuit operation including high frequency effects, noise properties, nonlinear effects.

899. Research

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

911. General Automata Theory I

(981.) Fall of odd-numbered years. 3(3-0) CPS 453 or 825 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

(982.) Winter of even-numbered years. 3(3-0) 911. Interdepartmental with and administered by the Computer Science Department.

Reliability and redundancy of finite automata. Probabilistic sequential machines. Languages definable by probabilistic and deterministic automata. Axioms for equivalence of regular expressions.

913. General Automata Theory III

(983) Spring of odd-numbered years. 3(3-0) 912. 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) 837.

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) 926.

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.

945. Mean Square Filtering and Prediction

Fall of even-numbered years. 3(3-0) 845.

Stationary and ergodic ensembles of signals; correlation functions; Wiener's solution to optimum filtering and prediction problems.

946. *Extraction of Signals from Noise*

Winter of odd-numbered years. 3(3-0) 945.

Auto-correlation and cross-correlation in detecting signals in noise; application of decision theory to the detection problem; measurement of message characteristics in noise.

947. *Space Communications*

Spring of odd-numbered years. 3(3-0) 847, 946.

Communication theory and switching theory applied to the study of communications in space; rate of information and error probability in pulse modulation systems for long distance communications.

955. *Microelectronics I*

Fall of odd-numbered years. 3(3-0) 853.

Basic physical principles underlying the operation, design, and fabrication of microelectronic devices.

956. *Microelectronics II*

Winter of even-numbered years. 3(3-0) 955.

Miniaturized components; thin-film networks; solid-state circuits and operational limitations.

957. *Semiconductor Switching Circuits*

Spring of even-numbered years. 3(2-3) 956 or approval of department.

Switching design considerations; theory and application of device characteristics in switching circuits. Laboratory experiments using transistors and microcircuits.

975. *Quantum Electromagnetics*

Winter of odd-numbered years. 3(3-0) 816.

Tensors; four-vector formulation of classical electromagnetics; relativistic electromagnetics; Lagrangian ond 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 Radiations in Plasmas*

Fall of even-numbered years. 3(3-0) 850. Interdepartmental with the Astronomy Department.

Plasma oscillation; interaction, electromagnetic fields with plasmas, wave propagation in magnetionic media; plasma sheath; radiation of electric source in incompressive and compressive plasmas; electroacoustic waves; magnetohydrodynamics; research topics in plasmas.

990. *Electromagnetic Wave Propagation I*

Winter of odd-numbered years. 3(3-0) 835.

Electromagnetic plane waves, collimated beams and pulses, phase velocity, group and signal velocity, velocity of energy transport, propagation of plane waves in homogeneous dispersive media, reflection of spherical wave from homogeneous boundaries, propagation in wave guides with complex boundaries.

991. *Electromagnetic Wave Propagation II*

Spring of odd-numbered years. 3(3-0) 990.

Propagation in monotonically stratified media, propagation in turbulent media (scattering), propagation in stratified media, propagation in quasi-periodic media, Brillouin scattering, pulses in inhomogeneous media, propagation in moving media, complex Doppler effect, coupling between Maxwell equations and continuum equations, depolarization of EM waves.

999. *Research*

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

Systems Science — SYS

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.

475. *Introduction to Operations Research*

Winter. 4(4-0) MTH 215, CPS 120. Interdepartmental with and administered by the Agricultural Engineering Department.

Methodology and basics of operations research; formulation and analysis of probabilistic models of inventory, waiting line, and reliability processes; random process simulation and network planning models.

801. *Special Problems*

Fall, Winter, Spring, Summer. 1 to 4 credits. May re-enroll for a maximum of 8 credits. Approval of department.

810. *Introduction to Linear System Theory*

(812.) Fall. 3(3-0) MTH 214. Interdepartmental with Computer Science Department and Social Science (College of).

A first course in system theory for students from a range of disciplines. Mathematical representation of system variables, transform and state space method of analysis, introduction to control theory, applications to physical, economic and social systems.

811. *System Methodology and Simulation*

Winter. 3(3-0) 810, STT 441. Interdepartmental with the Computer Science Department and Social Science (College of).

Problem definition, design of abstract models for system design and control, simulation of systems described by differential and difference equations, generation of random variables, simulation of discrete object stochastic systems, simulation languages, applications to physical, economic and social systems.

813. *System Project*

Spring. 3(1-6) 811. Interdepartmental with the Computer Science Department and Social Science (College of).

Individual or team application of simulation methods to system design and/or management.

825. *Foundations of Systems Science*

Spring, Summer. 4(4-0) MTH 215 and 334.

Basic definitions; set theory, graph theory, matrices and vector differential and difference equations in system theory; solutions in terms of functions of matrices and operational calculus.

826. *Linear Concepts in Systems Science*

Fall. 4(4-0) 825.

State-space and frequency domain models of interconnected systems; solution of continuous and discrete-time linear systems; response characteristics; stability.

827. *Nonlinear Concepts in Systems Science*

Winter. 4(4-0) 826.

Existence, uniqueness and stability; autonomous systems and the phase space; linearization, perturbation, describing functions and harmonic balance procedures; numerical solutions.

828. *Optimization of Static Nonlinear Systems*

Winter, Summer. 3(3-0) CHE 465 or knowledege of linear programming. Interdepartmental with the Department of Chemical Engineering.

Problem formulation and classification, Kuhn Tucker theory in nonlinear programming, gradient and search methods, techniques for quadratic, integer, geometric, and dynamic programming.

847. *Analysis of Stochastic Systems*

Spring. 3(3-0) E E 846.

Equilbrium properties of non-stationary random processes; problems or estimation, filtering and prediction; sequential and recursive decision schemes; applications of random process theory to system modeling.

888. *Hybrid Computation*

Spring. 3(3-0) Approval of department.

Hybrid programing techniques, applications in simulation design, control and optimization.

899. *Research*

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

961. *Optimal Control Theory I*

Fall. 3(3-0) 827, 828 or approval of department; MTH 426.

Formulation of the general control problem; controlability, observability and normality in discrete-state and continuous-state systems; performance functionals; typical control problems.

962. *Optimal Control Theory II*

Winter. 3(3-0) 961.

Optiman control theory in continuous-state and discrete-state systems; necessary and sufficient conditions for optimal solutions, geometric interpretations relation to calculus of variations; typical applications.

963. *Optimal Control Theory III*

Spring. 3(3-0) 962 or approval of department.

Topics selected among: computational methods for optimal controls (solution of selected two-point boundary value problems); stochastic control theory; state estimation, Kalman filtering and related statistical methods; differential game theory.

965. *Special Topics in Optimal Process Theory*

Spring of odd-numbered years. 3(3-0) 828 or approval of department. Interdepartmental with and administered by the Chemical Engineering Department.

Continuation of 828 and special topics from the literature in non-linear, stochastic, and dynamic programming.

999. *Research*

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