ELECTRICAL ENGINEERING AND SYSTEMS SCIENCE

College of Engineering

Electrical Engineering

Electrical Engineering

305. Electromagnetic Fields and Waves I
Fall, Winter. 3(3-0) MTH 215, PHY 288.

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; 307 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 324; 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 analogy 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; ac-

*Effective March 1, 1969.

curacy 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.

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, bistable and hysteric 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, appropriate to topics covered in 374.

386. Electronics Laboratory II
Spring, Summer. 1(0-3) 376 concurrently.

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 methods; 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 amplifier, algorithms for digital control, organization of digital controllers.

418. Introduction to Network Synthesis
Spring. 3(3-0) 313.

435. Guided Transmission Systems
Fall. 3(3-0) 308.
Electric circuit theory from EM field theory. Guided wave theory: normal modes, propagation characteristics, wave 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 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 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.

469. 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) 459; 457 concurrently.
Experimental investigations on communication theory and information transmission topics from 455, 456, and 457.
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 and effects and devices; single-junction and multiple-junction devices; sources of optical radiation, including lasers; methods of detecting optical radiation; solar cells; thermal and electromagnetic 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; computer-aided design of electronic devices; measurement of bulk properties of materials; computer-aided analysis of electronic devices.

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 electronic devices.

801. Special Problems
Fall, Winter, Spring. 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 electronic tubes, transistors, beam and parametric devices, amplifiers, mixers, and detectors; techniques and equipment for noise measurements.

818. Electrical Properties of Materials I
Winter of odd-numbered years. 3(3-0)
Study of atomic and molecular properties affecting the conductivity, permittivity, permeability, absorptivity, and radiativity of materials, classical and quantum considerations.

819. Electrical Properties of Materials II
Spring of odd-numbered years. 3(3-0)
Temperature and frequency effects on conduction, dilectric constant, and dielectric loss; temperature, frequency, and bias effects on the behavior of ferroelectric 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 impedances; 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, Chebychev 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; calculation of impedance; propagation of electromagnetic wave in isotropic anisotropic media; skin effects; boundary value problems.

837. Guided Transmission Systems
Spring. 3(3-0) 835.
Electromagnetic fields in open-line wires, coaxial lines, and wave guides; power and energy relationships; orthogonal propagation; 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; random processes; correlation functions; 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 principles of parametric electromagnetics.

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; microwave devices; solid state microwave electronics.

850. Ionized Cases
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 fields; 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
(3CR 885). Fall, Winter, Spring.
Variable credit. Approval of department.

911. General Automata Theory I
Fall of even-numbered years. 3(3-0) CPS 453 or 525 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) 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
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)
Linear antennas; cylindrical dipole antennas as radiating functions; Wessel's solution; 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(3-0)
637, 927, 989.
Experiments on transmission line systems; scattering measurements; antenna measurements; interaction of electromagnetic waves with plasma; radiation in plasmas; experiments on electron tubes and on lasers.

945. Mean Square Filtering and Prediction
Fall of even-numbered years. 3(3-0)
Stationary and ergodic ensembles of signals; correlation functions; Wessel's solution to optimum filtering and prediction problems.
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**

**(Fall.) 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(1-4) 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.

997. **Research (EGR 999.)**

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

827. **Nonlinear Concepts in Systems Science**

**Winter. 4(4-0) 826.**

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

828. **Optimization of Static Nonlinear Systems**

**Winter. Summer. 3(3-0) CHE 465 or knowledge 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.**

Equilibrium properties of non-stationary random processes; problems of 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 programming techniques, applications in simulation design, control and optimization.

890. **Research**

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

961. **Optimal Control Theory I**

**Fall. 3(3-0) 927, 928 or approval of department; MTH 426.**

Formulation of the general control problem; controllability, 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.**

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

963. **Optimal Control Theory III**

**Spring. 3(3-0) 968 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) 826 or approval of department. Interdepartmental with and administered by the Chemical Engineering Department.**

Continuation of 826 and special topics from the literature in non-linear, stochastic, and dynamic programming.

999. **Research**

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