968B. *Research Analysis in Personnel Work*

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

Critical review of research and literature in counseling and personnel services.

969. *Quantitative Methods in Educational Research*

B. Advanced Quantitative Methods in Educational Research.

Fall, Winter, Summer. 4(3-1) 869 or pretest and approval of instructor.

Principles and techniques in the application of inferential statistics to educational data with emphasis on the analysis of variance and multiple comparison procedures. Overview of regression techniques.

C. Experimental Design in Education.

Winter, Spring, Summer. 4(3-1) 969B.

Theory and practice in the design, analysis, and interpretation of experimental and quasi-experimental research.

970. *Reading and Research in Student Teaching*

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

Literature, research and practice in teacher education field experiences. Concentration on issues, problems and skills needed in supervision of student teachers.

973. *College Student Personnel Administration I*

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

Emphasis on planning, organization, financing, research, evaluation and administration for programs and services which exist principally to serve individual student needs: counseling, orientation, health, placement, financial aids, etc.

974. *College Student Personnel Administration II*

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

Student organizations and activities; student union; on and off-campus living environments. Emphasis on planning, organization, financing, research, evaluation and administration of these programs and services.

975. *College Student Personnel Administration III*

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

Analysis of student rights and responsibilities; academic freedom; regulation of student conduct; systems of governance and judicial processes; legal basis for student personnel programs and administration.

982. *Seminars in Education*

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

Seminars in the various fields of emphasis.

983. *Readings and Independent Study in Education*

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

Study on an individual or group basis in the various fields of emphasis.

984. *Laboratory and Field Experience in Education*

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

Supervised advanced graduate practicums, observation, internships, and externships in the various areas of emphasis.

985. *Counseling Pre-Practicum*

Spring. 3(2-1) Doctoral status in college counseling or related area and approval of department.

Seminar emphasizing establishing good interpersonal relationships, self-understanding, an understanding of psychodynamics, and test interpretation as preparation for assuming counseling responsibilities. Approach is didactic and experiential with limited contacts with clients.

986A. *Counseling Practicum I*

Fall. 3(0-3) 985 or approval of department.

Supervised experience working with college students in a counseling relationship. Group discussions, 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 discussions, 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 in the residence halls. Individual supervision, increased client contact hours, and participation in staff activities.

987A. *Seminar: Continuing Education and Social Policy*

Fall. 3(3-0) May re-enroll for a maximum of 6 credits. Majors 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(3-0) May re-enroll for a maximum of 6 credits. Majors 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 — E E

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.

300. *Electric Circuits I*

Fall, Winter. 4(4-0) MTH 113.

Current voltage and power. DC and transient circuit analysis. Forced response. Sinusoids and the phasor concept. Bridges.

301. *Electric Circuits II*

Winter, Spring. 4(4-0) 300, MTH 214.

Sinusoidal steady-state response. Average power and rms concepts. Complex frequency response. Magnetically coupled circuits. Two-port networks. Transfer functions.

302. *Basic Electronic Circuits*

Spring, Summer. 4(4-0) 301, MTH 215.

Volt-ampere characteristics of diodes and transistors. Voltage, current and power amplification. Stability, transient and high-frequency effects. Feedback, oscillators and operational amplifiers.

303. *Electronics Laboratory I*

(384.) Winter, Spring. 1(0-3) 300; 301 concurrently.

Electronic test equipment and measurement fundamentals. Experimental verification of topics covered in 300 and 301. Computer-aided circuit analysis and design.

304. *Electronics Laboratory II*

(386.) Fall. 1(0-3) 302.

Experimental verification of topics covered in 302. Single-stage and multistage transistor amplifier design and analysis. Applications of linear integrated circuits. Computer-aided circuit design.

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.

345. *Introduction to Electronic Instrumentation Systems*

Fall, Winter, Spring. 4(3-3) PHY 288.

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 Design*

Winter. 3(3-0) SYS 313. Interdepartmetnal with Systems Science.

Controller design via root locus and frequency response methods; controllability, observability; state-space design techniques for continuous and computer-controlled feedback systems; survey of digital control.

418. *Introduction to Computer-Aided Circuit Design*

Spring. 3(3-0) CPS 120, E E 302.

Introduces the techniques used for automatic formulation, analysis and optimization of linear and non-linear electronic circuits. Students will write a modest but useful analysis program package.

419. *Physical Phenomena and Electronic Instrumentation I*

Winter. 4(3-3) PHY 289, MTH 215. Interdepartmental with and administered by the Department of Physics.

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.

420. *Electromechanical Energy Conversion*

Winter. 3(3-0) 301, 305.

Review of electromagnetics; design, specification, and use of d.c. machines in industrial and servo-control application, synchronous generators and transformers for power systems; three phase power, per unit notation.

421. *Power System Analysis*

Spring. 3(3-0) 420.

Model of power system components; analysis and planning techniques including load flow, short circuit, transient stability; voltage and frequency control; economic operation of power systems.

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) 430 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) May re-enroll for a maximum of 2 credits. 431 or concurrently.

Design, construct and test representative digital electronic circuits. Hands-on experience with minicomputer, microcomputers and programmable calculators. Applications in data acquisition and control.

435. *Guided Transmission Systems*

Fall. 3(3-0) 307.

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.

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.

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.

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 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. *Statistical Communication Systems*

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.

464. *Control Systems Laboratory*

Fall. 2(1-3) 303 or 345; 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.

467. *Communications Laboratory*

Spring. 1(0-3) 456; 457 concurrently.

Experimental investigations on communication theory and information transmission topics from 455, 456, and 457.

474. *Physical Principles of Electronic Devices*

Fall. 3(3-0) 302; PHY 288.

Energy levels in atoms and crystals. Density of states. Fermi-Dirac statistics. Transport properties of bulk materials. Metal-semiconductor contacts. The pn junction and BJT.

475. *Electronic Devices and Circuits I*

Winter. 3(3-0) 474.

Analysis and design of devices and circuits based on principles discussed in 474. Physical models for BJT's and FET's. Power devices and circuits. High-frequency and high-speed devices and circuits.

476. *Electronic Devices and Circuits II*

Spring. 3(3-0) 307 and 475.

Continuation of topics covered in 475. Microwave vacuum and solid-state devices. Solid-state energy-conversion devices. Opteoelectronic devices and applications. Charge-coupled devices and applications.

480. *Integrated Circuits: Operational Amplifiers*

Spring. 3(3-0) 302.

Integrated circuits: design principles and fabrication. Differential-amplifier stage signal characteristics. Properties and models of operational amplifiers. Applications: signal conditioners, signal processors, signal generators, and special-purpose circuits.

484. *Electronic Devices Laboratory I*

Winter. 1(0-3) 474; 475 concurrently.

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

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.

Exposition 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 E E 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 E E 499 and SYS 499 combined. Approval of department.

Independent undergraduate research in contemporary areas of electrical engineering such as: alternative energy, monitoring and control, bioengineering, 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.

831. Active Network Synthesis

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

S-domain network synthesis. Root-locus design techniques for practical analog signal processors, including sensitivity and stability considerations. Passive network synthesis and functional properties of operational amplifiers.

835. 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 waves, plane waves, cylindrical waves, spherical waves.

836. Electromagnetic Theory II

Winter. 3(3-0) 835.

Electromagnetic radiation from simple antennas; analysis of transmitting and receiving systems; propagation of electromagnetic waves in various media; electromagnetic fields in open-wire lines and waveguides.

837. Guided Transmission Systems

Spring. 3(3-0) 836.

Discontinuities and impedances in waveguides; equivalent circuits of microwave devices; waveguide excitations; scattering matrix, resonant cavities; microwave circuits.

846. Analysis of Random Time Functions

Winter, 3(3-0) Approval of department.

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

Spring. 3(3-0) 846.

Statistical communication theory, vector representation of waveforms; matched filters; detection theory; digital communication systems, PCM, efficient signaling sequences estimation theory; AM and FM, modulation.

849. Microwave Electronics

Spring. 3(3-0) 835, 875.

Microwave solid-state devices, parametric amplifiers, waves in vacuum and solid-state plasmas, wave amplifiers and oscillators, design of microwave systems.

850. Ionized Gases

Spring. 3(3-0) 835 or PHY 448. 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.

861. Bioelectric Field Theory

Spring. 3(3-0) 306, BME 411.

Volume conductor fields: quasi-static formulation, bioelectric sources, boundary conditions, field of a single cell, subthreshold neuron phenomena, integral equations for biopotentials. Electrocardiography: bioelectric sources in heart, dipole hypothesis, forward and inverse problems.

874. Physical Electronics

Fall. 4(4-0) Approval of department.

Application of quantum mechanics in solids, band theory of semi-conductors, electrical transport phenomena, induced current concept, charged particle dynamics, electron optics.

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.

Continuous and discrete signals — generation, representation and classification. Fourier transform, spectral analysis and filtering for continuous and discrete signals. Computer implementation of signal processing.

899. Research

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 Department of Computer Science.

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 Department of Computer Science.

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

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.

975. Quantum Electromagnetics

Winter of odd-numbered years. 3(3-0) 874.

Emission, absorption and amplification of radiation; energy levels for optically active materials; kinetic modeling of plasmas and chemically reacting plasmas; rate equation modeling and empty cavity modes of lasers and masers.

976. Lasers and Masers

Spring of odd-numbered years. 3(3-0) 975.

Advanced modeling of lasers and masers, quantization of wave fields, line width, multimode phenomena, mode locking, ring and Zeeman lasers, recent developments and applications.

989. Waves and Radiations in Plasmas

Fall of even-numbered years. 3(3-0) 850. Interdepartmental with the departments of Astronomy and Astrophysics and Physics.

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.

999. Research

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

Systems Science SYS

IDC. Introduction to Environmental Systems

For course description, see **Interdisciplinary Courses.**

311. Discrete-Time Systems

Fall, Winter. 3(3-0) MTH 215.

Discrete-time system modeling, discrete-time signals, difference equations, convolution summations, z-transform, transfer functions, stability analysis, digital filters.

312. Continuous-Time Systems

Winter, Spring. 3(3-0) 311.

Response of linear discrete-time systems from transfer functions. Digital filters. Discrete and continuous state-space representation; response of linear systems from state models.

313. Analysis of Control Systems

Spring, Summer. 3(3-0) 312.

Control system characteristics, performance criteria, transient and steady-state responses, error analysis, stability, root locus method, frequency response techniques, gain and phase margins.

404. Biological and Ecological Concepts for Engineers and Mathematicians

Winter. 3(3-0) Approval of department. Interdepartmental with and administered by the Department of Zoology.

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 Department of Engineering.

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. 2(3-0) 410. Interdepartmental with the Department of Engineering.

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.

415. Control Systems Design

Winter. 3(3-0) 313. Interdepartmental with and administered by Electrical Engineering.

Controller design via root locus and frequency response methods; controllability, observability; state-space design techniques for continuous and computer-controlled feedback systems; survey of digital control.

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 Department of Chemical Engineering.

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 Department of Agricultural Engineering.

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.

490. Special Topics in Systems Science

Fall, Winter, Spring, Summer. 1 to 4 credits. May re-enroll for a maximum of 12 credits. Approval of department.

Exposition of special topics in systems science.

495. Independent Study

Fall, Winter, Spring, Summer. 1 to 3 credits. May re-enroll for a maximum of 3 credits in SYS 495 and E E 495 combined. Approval of department.

Independent study of a topic in systems science of particular interest to the student.

499. Undergraduate Research

Fall, Winter, Spring, Summer. 1 to 3 credits. May re-enroll for a maximum of 6 credits in SYS 499 and E E 499 combined. Approval of department.

Independent undergraduate research in contemporary areas of systems science.

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

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

814. Advanced System Methodology and Simulation

Spring. 3(3-0) 811. Interdepartmental with the Department of Computer Science.

Simulation of a class of time-varying distributed parameter processes; organization and design of large simulation models; optimization and parameter estimation in large simulation models; applications to economic, social and biological systems; other topics of current interest.

820. System Dynamics and Control

Spring. 4(4-0) MTH 215; knowledge of matrices and Laplace transforms.

Fundamentals of continuous and discrete dynamic control systems; feedback principles; transform and state variable design techniques; introduction to optimal control design.

826. Linear Concepts in Systems Science

Fall. 4(4-0) Approval of department.

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 in nonlinear systems; autonomous systems and the phase space; linearization, perturbation, describing functions and harmonic balance procedures; numerical solutions.

835. Nonlinear Optimization Models

(828.) Winter, Summer. 4(4-0) Students may not receive credit for both SYS 835 and MGT 835. CHE 465 or MGT 834 or knowledge of linear programming. Interdepartmental and jointly administered with the departments of Management and Chemical Engineering.

Nonlinear optimization-examples and applications. Kuhn-Tucker Theory. Saddle point optimality conditions. Algorithms for problems with constraints. Unconstrained optimization; introduction to search methods.

841. Optimization of Urban Traffic Flow

Fall of odd-numbered years. 3(3-0) Approval of department. Interdepartmental with Civil Engineering.

Traffic flow models used in design of computerized traffic control systems. Optimal freeway ramp metering algorithms. Offline and online optimization of traffic signal timing.

843. Ecosystem Analysis, Design and Management

Spring. 3(3-0) 442 or ZOL 404. Interdepartmental with the Department of Zoology.

Groups of students from various biological and non-biological disciplines will synthesize and analyze models of selected biological systems. Projects should yield information relevant to solution of contemporary ecological problems.

851. Modeling of Engineering Systems

Fall. 4(4-0) M E 458 or E E 415. Interdepartmental with and administered by the Department of Mechanical Engineering.

Modeling of engineering devices and components; assembly into systems; bond graph representation; prediction of dynamic behavior by linear, nonlinear and simulation methods; applications to mechanical, electrical, fluid, thermal systems.

899. Research

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

961. Optimal Control Theory I

Fall. 3(3-0) 827, 835 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 or approval of department.

Optimum 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 Estimation and Control Theory

Spring. 3(3-0) 962 or E E 847 or approval of department.

Techniques of optimal control and communication theory; development of stochastic control and detection models, state estimation, Kalman filtering, stochastic control, computational methods.

965. Special Topics in Optimal Process Theory

Spring of odd-numbered years. 3(3-0) 835 or approval of department. Interdepartmental with and administered by the Department of Chemical Engineering.

Continuation of 835 and special topics from the literature in nonlinear, stochastic and dynamic programming.

999. Research

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