976A. *Fieldwork Research in Educational Settings I*

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

Substantive and methodological issues in planning and conducting fieldwork research in educational settings. Knowledge and skills necessary to evaluate quality of fieldwork research. Critical review of examples of research reports.

976B. *Fieldwork Research in Educational Settings II*

Winter. 3(3-0) ED 976A or approval of instructor.

Supervised fieldwork research in educational settings. Techniques of data collection and analysis. Research question formation, entry, evidence, and ethics.

976C. *Fieldwork Research in Educational Settings III*

Spring. 3(3-0) ED 976B.

Supervised analysis and reporting of fieldwork research data. Literature review, model construction, analysis of field notes and other data. Preparing narrative reports addressed to scientific audiences and to audiences of practitioners.

977. *Teacher Assessment and Development*

Fall. 3(3-0) Completion of 27 credits at graduate level.

Concepts of teacher assessment, techniques and instruments for analysis of teaching, current assessment practices, and strategies for teacher development based on needs.

978. *Professional Lectures in Educational Administration.*

Fall. 3(3-0) Graduate students in Educational Administration.

Lectures by faculty in Educational Administration in individual faculty research and service interests, exploration of recent research and other scholarly publications.

979. *Community College Administration*

Fall, Spring, Summer. 3(3-0) ED 822A.

Functional areas of community college administration with emphasis upon instruction, finance and student services including the importance of local, state and federal influences.

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 psychodynmics, and test interpretation as preparation for assuming counseling reponsibilities. Approach is didatic and experimental with limited contacts with clients.

986. *Group Processes in Counseling Psychology*

Fall. 3(3-0) Graduate students.

Didactic-experiential format to explore group dynamics, interpersonal processes within groups, differential effect of various leadership styles, facilitation of group interaction, impact of different theoretical approaches, application to counseling/school settings.

986A. *Counseling Practicum I*

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

Supervised experience working with college students in a counseling relationship. Group discussions, group supervision and orbservation of counseling interviews, and individual supervision.

986B. *Counseling Practicum II*

Winter. 3(3-0) ED 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) ED 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 reenroll 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 reenroll 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 reenroll 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.

989. *Laboratory and Field Experience in Counseling Psychology*

Fall. 3(2-4) Counseling psychology majors.

Applied aspects of counseling through case conferences and presentations of cases by representatives of various counseling orientations.

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 reenroll for a maximum of 18 credits. Approval of department.

Supervised graduate practicum or internship in special education administration.

991. *Higher Education Internship*

Fall, Winter, Spring, Summer. 3(0-9) May reenroll for a maximum of 12 credits. Doctoral and Educational Specialist students in Higher Education and approval of instructor.

Students intern in on- and off-campus offices and agencies as observers of and participants in the administration of programs particular to their major field of study.

996. *Physiological Measurement in Counseling Psychology*

Spring. 3(2-2) ED 414 and approval of department.

Physiological measurement in counseling psychology treatment, training, and research.

999. *Doctoral Dissertation 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, stereoamplifiers, 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) E E 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) E E 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*

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

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

304. *Electronics Laboratory II*

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

Experimental verification of topics covered in E E 302. Single-stage and multi-stage 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 310, PHY 288.

Vector analysis, Electrostatic fields; EM sources, scalar potential, Poisson's and Laplace's equations, dieletric media, capacitance, and energy storage. Boundary value problems for electronstatic fields.

306. *Electromagnetic Fields and Waves II*

Winter, Spring. 3(3-0) E E 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 EM boundary-value problems.

307. *Electromagnetic Fields and Waves III*

Spring, Summer. 3(3-0) E E 306; E E 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) E E 306; E E 307 concurrently.

Experimental investigation of: charged particle motion in EM fields, dieletric 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. Interdepartmental 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 nonlinear 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, PHY 298 or approval of department, 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) E E 301, E E 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) E E 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) E E 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) E E 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 reenroll for a maximum of 2 credits. E E 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) E E 307.

Guided wave theory; normal modes, propagation characteristics in rectangular and circular waveguides. Stripline and microstrip. Electromagnetic resonators; frequency and Q. Circuit theory of waveguiding systems. Scattering matrix; system applications.

436. *Radiation and Propagation of Electromagnetic Waves*

Winter. 3(3-0) E E 307.

Radiation, propagation, scattering and reception of electromagnetic waves; circuit and radiation characteristics of wire and microwave and antennas; radiation fields, self and mutual impedances of antennas and arrays; microwave aperture antennas.

438. *Transmission and Radiation Laboratory*

Winter. 1(0-3) E E 435; E E 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) E E 455 or approval of department.

Probability theory applied to communications. Representation of random signals as stochastic processes. Autocorrelation and spectral density. Noise in components and systems, performance of analog linear and nonlinear systems with noise.

457. *Statistical Communication Systems*

Spring. 3(3-0) E E 456; E E 467 concurrently.

Representation, processing and filtering of random signals. Performance of digital systems with noise. Optimal digital communications systems. Signal detection, information concepts, coding. Communication systems such as radar, television, PCM, and telephony.

464. *Control Systems Laboratory*

Fall. 2(1-3) E E 303 or E E 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) E E 456; E E 457 concurrently.

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

474. *Physical Principles of Electronic Devices*

Fall. 3(3-0) E E 302; E E 305.

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

475. *Electronic Devices and Circuits I*

Winter. 3(3-0) E E 474.

Analysis and design of devices and circuits based on principles discussed in E E 474. Physical models and operations for BJT's, FET's and other semiconductor devices.

476. *Electronic Devices and Circuits II*

Spring. 3(3-0) E E 307, E E 475.

Continuation of topics covered in E E 475. Power semiconductor devices, solid state energy-conversion devices. Opteoelectronic devices and applications. High-frequency device design, models and applications.

477. *Electro-optic Devices*

Spring of odd-numbered years. 3(3-0) E E 306.

Atomic origin and the operational characteristics of light sources and detectors. Basic design considerations for gas and solid state lasers. Methods of optical detection, applications.

480. *Integrated Circuits: Operational Amplifiers*

Spring. 3(3-0) E E 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*

Winter. 1(0-3) E E 475 concurrently.

Measurement of semiconductor bulk properties. Device fabrication. Experimental study of selected electron devices and design application based on principles discussed in E E 474 and E E 475.

490. *Special Topics in Electrical Engineering*

Fall, Winter, Spring, Summer. 1 to 4 credits. May reenroll 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 reenroll 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 to the student.

499. *Undergraduate Research*

Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll 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.

809. *Computer Arithmetic Algorithm Design*

Fall. 4(4-0) E E 431 or CPS 423. Interdepartmental with the Department of Computer Science.

Number systems; fast two-operand and multioperand addition/subtraction; standard, recoded and cellular array multipliers; high-performance dividers; floating-point arithmetic; error control; pipelining.

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.

822. *Analysis of Faulted Power Systems*

Winter. 4(4-0) SYS 826.

Symmetrical components; models of generators, transformers, transmission lines; calculation of short circuits for symmetrical and unsymmetrical faults; system protection devices and practice.

823. *Power System Stability and Control*

Fall of even-numbered years. 3(3-0) SYS 826.

Analysis and simulation of small and large disturbance stability of power systems; generator, exciter, voltage regulator models; design of excitation systems and power system stabilizers.

826. *Advanced Linear Systems' Analysis*

Fall. 4(4-0) MTH 310, MTH 334. Interdepartmental with and administered by Systems Science.

Unified analysis of linear continuous-time and discrete-time systems for both time-invariant and time-varying models; mathematical descriptions, transforms, state models; transition matrices; solution techniques; controllability; observability; stability.

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*

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

Electrostatics, magnetostatics, electrodynamics and Maxwell's equations. Green's function and eigenfunction expansion techniques. Conservation of EM energy and momentum. Radiation of EM waves: Lorentz potentials, Helmholtz integrals, retarded potentials, general EM field.

836. *Electromagnetic Waves I*

Winter. 3(3-0) E E 835.

EM description of circuits. EM boundary-value problems. Hertzian potentials. Field equivalence theorems. Green's functions. TEM waves: propagation in curvilinear coordinates, transmission and scattering coefficients. Transmission lines: variational methods, microstrip.

837. *Electromagnetic Waves II*

Spring. 3(3-0) E E 836.

Guided transmission systems. Modes of metallic and open-boundary dielectric waveguides and cavities. Mode orthogonality. Excitation and coupling. Scattering by waveguide discontinuities. Radiation modes. Fiber and integrated optics.

841. *Fourier Optics*

Spring of even-numbered years. 3(3-0) E E 455 or E E 880, E E 307 or E E 835.

Electromagnetic (Fourier) optics and optical information processing. Spatial linear systems, EM optics and scalar diffraction; lenses; optical imaging systems; optical information processing; holography.

847. *Communication Engineering*

Fall. 4(4-0) E E 456 or approval of instructor. Interdepartmental with Systems Science.

Communications in probabilistic channels. Measures in system performance. Channel models. Optimal reception of analog and digital signals. Coding for various channel models. Detection of targets. Signal solution.

848. *Communication Theory*

Spring. 3(3-0) E E 847, E E 880, E E 863. Interdepartmental with Systems Science.

Hypothesis testing, decision theory and parameter estimation in communications and signal processing. Optimal filtering techniques. Communication in non-white noise. Communication in non-Gaussian noise. Quantum detection theory.

849. *Microwave Electronics*

Spring of odd-numbered years. 3(3-0) E E 835, E E 875.

Microwave gaseous, solid-state and vacuum devices, active microwave integrated circuits and systems, waves in solid-state plasmas and their applications, parametric amplifiers. Design of microwave amplifiers, oscillators and communication systems.

850. *Electrodynamics of Plasmas I*

Fall. 3(3-0) E E 835 or PHY 448; E E 874. Interdepartmental with the departments of Astronomy and Astrophysics, and Physics.

Boltzmann equation; moment equations; two-fluid theory of plasma, waves in cold, warm and anisotropic infinite plasma; waves in bounded plasma structures, energy flow in anisotropic plasmas.

863. *Analysis of Stochastic Systems*

Winter. 3(3-0) E E 415, E E 456. Interdepartmental with and administered by Systems Science.

Analysis and modeling of stochastic signals and systems. Topics include stochastic models, description of processes, stationarity, ergodicity, correlation and power spectrum, linear stochastic systems, harmonic analysis, Markov processes, Poisson processes.

871. *Integrated Circuit Engineering*

Spring. 3(3-0) E E 475.

Design, fabrication, and selected applications of silicon, thin film, and thick film integrated circuits. Physics and chemistry of processing, current technologies and limitations. Measurement, testing, and reliability considerations.

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. *High Speed Solid-State Devices*

Winter. 3(3-0) E E 474.

Formulation of operating properties and appropriate models of devices formed with semiconductors and solid state materials. Emphasis is on performance limitations of high speed integrated circuit unipolar and bipolar devices.

876. *Semiconductor Power Devices*

Spring of even-numbered years. 3(3-0) E E 474.

Formulation of operating properties and appropriate models of devices formed with semiconductors and solid state materials. Performance limitations of semiconductor power devices due to voltage, temperature and power considerations.

880. *Signal Analysis*

Winter. 3(3-0) Approval of department. Interdepartmental with Systems Science.

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. *Master's Thesis 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) CPS 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) CPS 912. Interdepartmental with and administered by the Department of Computer Science.

Degrees of difficulty of computation. Models of parallel computation. Iterative automata.

921. Advanced Computer Systems I

Fall of odd-numbered years. 3(2-3) CPS 827; graduate course in operating systems. Interdepartmental with and administered by the Department of Computer Science.

Models of single and multiple processors, their computational power, and measures of performance. Interconnection networks, data driven machines, and pipelines.

922. Advanced Computer Systems II

Winter of even-numbered years. 3(2-3) CPS 921. Interdepartmental with and administered by the Department of Computer Science.

Design and characterization of parallel algorithms. Matching of algorithms with appropriate hardware configurations. Programming languages which support parallel computation.

926. Antenna Theory I

Winter of even-numbered years. 3(3-0) E E 835.

Wire antennas as radiating, receiving and scattering elements; analytical and numerical integral equation methods; coupled antennas and arrays; transient phenomena.

927. Antenna Theory II

Spring of even-numbered years. 3(3-0) E E 926.

Radiation by equivalent aperture fields; aperture antennas, slot antennas, horn and reflector antennas, frequency independent antennas; pattern theory; scattering from various objects.

929. Advanced Topics in Electromagnetics

Fall, Winter, Spring, Summer. 2 to 4 credits. May reenroll for a maximum of 4 credits. E E 835 and approval of department.

Topics will be drawn from contemporary research areas such as transient electromagnetics (SEM solutions), open-boundary waveguides, solid-state lasers, and microwave plasmas.

931. Electronic Properties of Semiconductors

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

Advanced treatment of phenomena basic to semiconductor materials and devices. Electronic transport, high field effects, recombination theory, electro-optical phenomena, experimental characterization techniques.

932. Topics in Solid State Device Research

(930.) Spring of odd-numbered years. 3(3-0) E E 874.

Relationship of solid state theory and material properties to device performance. Topics selected from current device research areas and vary with year. Examples are photovoltaic, amorphous semiconductor, and piezoelectric devices.

947. Topics in Communications

Fall of odd-numbered years. 3(3-0) May reenroll for a maximum of 6 credits. E E 848. Interdepartmental with Systems Science.

Advanced treatment of a topic or group of topics of current research interest in the field of communications, information theory and signal processing.

975. Quantum Electromagnetics

Winter of odd-numbered years. 3(3-0) E E 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) E E 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. Electrodynamics of Plasmas II

Winter of odd-numbered years. 3(3-0) E E 850. Interdepartmental with the departments of Astronomy and Astrophysics, and Physics.

One fluid plasma model, magnetohydrodynamics, Maxwell's stress tensor, low frequency waves, transport phenomena, Landau damping, collision and rate coefficients. Diffusions in a magnetic field; investigation of dc, rf and microwave discharges.

999. Doctoral Dissertation Research

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

Systems Science SYS

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) SYS 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) SYS 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) MTH 113, CPS 110 or CPS 120. Interdepartmental with 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) SYS 410. Interdepartmental with Engineering.

Completion of a systems study initiated in SYS 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) SYS 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) E E 303 or E E 345; SYS 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. 3(3-0) MTH 310. 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 310, 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.

495. Independent Study

Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll 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 reenroll 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 reenroll for a maximum of 8 credits. Approval of department.

810. Introduction to Linear System Theory

Fall. 3(3-0) MTH 214. Interdepartmental with 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) SYS 810, STT 441. Interdepartmental with 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) SYS 811. Interdepartmental with 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) SYS 811.

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.

826. Advanced Linear Systems Analysis

Fall. 4(4-0) MTH 310, MTH 334. Interdepartmental with Electrical Engineering.

Unified analysis of linear continuous-time and discrete-time systems for both time-invariant and time-varying models; mathematical descriptions, transforms, state models; transition matrices; solution techniques; controllability; observability; stability.

827. Nonlinear Concepts in Systems Science

Winter. 4(4-0) SYS 826.

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

829. Modern Control Systems

Spring. 4(4-0) STT 441, SYS 826.

Stochastic processes and white noise; analysis of linear continuous-time control systems; state feedback design; state observer design; optimal linear control and Kalman filter; linear discrete-time control systems.

835. Nonlinear Optimization Models

Winter, Summer. 4(4-0) Students may not receive credit for both SYS 835 and MGT 835. MTH 215 or MTH 228; MGT 834 or CHE 465. Interdepartmental and jointly administered with the Department of Management. Interdepartmental with the Department of 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.

838. Feasibility Analysis of Energy Systems

Spring. 3(3-0) STT 441.

Methods for selecting energy conversion and transmission facilities with emphasis on electric utilities. Demand forecasting system reliability; selection of size, type and location of conversion facilities; cost analysis.

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) SYS 442 or ZOL 404. Interdepartmental with the Department of Zoology.

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

847. Communication Engineering

Fall. 4(4-0) E E 456 or approval of instructor. Interdepartmental with and administered by Electrical Engineering.

Communications in probabilistic channels. Measures in system performance. Channel models. Optimal reception of analog and digital signals. Coding for various channel models. Detection of targets. Signal solution.

848. Communication Theory

Spring. 3(3-0) E E 847, E E 880, E E 863. Interdepartmental with and administered by Electrical Engineering.

Hypothesis testing, decision theory and parameter estimation in communications and signal processing. Optimal filtering techniques. Communication in non-white noise. Communication in non-Gaussian noise. Quantum detection theory.

851. Modeling of Engineering Systems I

Fall. 3(3-0) M E 458 or E E 415. Interdepartmental with and administered by the Department of Mechanical Engineering.

Modeling of engineering components and dynamic systems; mechanical, electrical, fluid, thermal, and transducer effects. Linear state-space responses, impedance methods. Simulation of linear models. Design project.

852. Modeling of Engineering Systems II

Winter. 3(3-0) M E 851. Interdepartmental with and administered by the Department of Mechanical Engineering.

Continuation of M E 851. Modeling of nonlinear dynamic systems. Applications of phase-plane and linearization methods. Simulation of nonlinear systems. Design project.

863. Analysis of Stochastic Systems

Winter. 3(3-0) E E 415, E E 456. Interdepartmental with Electrical Engineering.

Analysis and modeling of stochastic signals and systems. Topics include stochastic models, description of processes, stationarity, ergodicity, correlation and power spectrum, linear stochastic systems, harmonic analysis, Markov processes, Poisson processes.

880. Signal Analysis

Winter. 3(3-0) Approval of department. Interdepartmental with and administered by Electrical Engineering..

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. Master's Thesis Research

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

947. Topics in Communications

Fall of odd-numbered years. 3(3-0) May reenroll for a maximum of 6 credits. E E 848. Interdepartmental with and administered by Electrical Engineering.

Advanced treatment of a topic or group of topics of current research interest in the field of communications, information theory and signal processing.

961. Optimal Control Theory

Fall. 3(3-0) SYS 827, MTH 426.

Optimal control, performance measures, principle of optimality, dynamic programming, Hamilton-Jacobi-Bellman equation, variational approach, constrained extrema, Pontryagin principle, necessary conditions, solution techniques, singular cases.

962. Computational Techniques for Optimal Control

Winter of odd-numbered years. 3(3-0) SYS 961.

Computational methods of optimal controls, steepest descent, variation of extremals, quasilinearization, gradient projection, dynamic programming, convexity techniques, support functions for reachable sets, current literature.

963. Dynamic System Identification and Control

Spring of odd-numbered years. 3(3-0) SYS 863, SYS 829.

System identification; dynamic programming; stochastic and adaptive control. Topics under identification include review of statistics background, dynamic system models, identification methods, recursive algorithms, input design, and structure discrimination.

964. Large Scale Dynamic Systems

Winter of even-numbered years. 3(3-0) SYS 961.

Model simplification; stability of large scale systems; decentralized control; optimization by decomposition and coordination; multilevel hierarchical control; applications.

999. Doctoral Dissertation Research

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