**951C. *Education Law***

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

Designed to discover general legal principles and examine laws and lawmaking agencies that affect educators and educational institutions and appropriate means to influence law development.

**951E. *Educational Personnel Administration***

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

Recruitment, selection, orientation, training, salary and fringe benefits, welfare, morale, negotiations, etc., to assist the administrator to function more effectively with personnel.

**951F. *Planning Change in Educational Organizations***

*Winter, Summer. 3(3-0) Approval of instructor.*

Analysis of research, theory and practice of the change process in educational organizations. Planned change concepts and methods are examined and tested by laboratory and field experiences.

**951H. *Field Research Methods in Education***

*Spring. 3(3-0)*

Methods of interview, participant observation or observation for carrying on educational research.

**951J. *Conflict Management in Educational Administration***

*Fall, Spring. 3(3-0) Approval of department.*

Theories, rationales, and strategies of conflict management. Managing conflict situations in educational environments.

**952A. *Externship in Educational Administration***

*Fall, Winter, Spring. 3 credits. May reenroll for a maximum of 27 credits. Present or past position as an educational administrator.*

Discussion of participants' current administrative problems and solution strategies, faculty visits to participants' schools and speakers on issues in educational administration.

**952B. *Multidisciplinary Seminar in Educational Administration***

*Fall, Winter, Spring. 3 credits. May reenroll for a maximum of 18 credits. 9 credits of EAD 952A.*

Discussion of generic problems and issues in administration identified and interpreted through selected readings and speakers from the several behavioral sciences.

**960. *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.

**964. *Adult Education: Program Planning***

*Spring. 3(3-0) EAD 860, EAD 861.*

Educational program planning and development for organizations that serve adult populations. Alternative program planning strategies to accomodate adult learner needs, organizational resources and desired outcomes.

**970A. *The Law of Higher Education***

*Fall, Spring. 3(3-0) Graduate students in College and University Administration; others, approval of instructor.*

Principles and cases of law applied to problems of governance, management, and instruction in post-secondary educational institutions. Emphasis upon personnel and student administration and equity issues.

**970B. *Higher Education Finance***

*(EAC 970B.) Fall, Spring. 3(3-0) Admission to M.A. or Ph.D. programs in the College of Education.*

Structures, processes and problems related to the financing of higher education in the United States. Emphasis on alternatives for the future.

**971A. *The Department in Higher Education***

*Winter. 3(3-0) Approval of instructor.*

The Department as an administrative structural element of the University. The duties and responsibilities of the chairperson as they relate to the management of the Department.

**971B. *Management Systems in Higher Education Administration***

*Fall, Spring. 3(3-0) Graduate students in College and University Administration; others, approval of instructor.*

The application of National Center for Higher Education Management Systems tools to decision making in higher education administration. Resource Requirement Prediction Model 1.6, student flow and faculty activity analysis are major tools investigated.

**971C. *Evaluation of Higher Education***

*Spring. 3(3-0) Graduate students in College and University Administration, EAD 872A or approval of instructor.*

Ways in which evaluation takes place in higher education; course examinations, grading, comprehensive examinations, teacher evaluation, institutional evaluation, state surveys, and regional and national studies of higher education problems.

**971D. *Community College Administration***

*Winter. 3(3-0) Graduate students in College and University Administration. Others, approval of instructor.*

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

**973A. *College Student Affairs Administration I***

*Fall. 3(3-0) Doctoral students in Student Affairs Emphasis. Others, approval of instructor.*

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.

**973B. *College Student Affairs Administration II***

*Winter. 3(3-0) Doctoral students in Student Affairs Emphasis. Others, approval of instructor.*

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.

**973C. *College Student Affairs Administration III***

*Spring. 3(3-0) Doctoral students in Student Affairs Emphasis. Others, approval of instructor.*

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.

**976A. *Doctoral Internship in College and University Administration***

*Fall, Winter, Spring, Summer. 3(0-9) May reenroll for a maximum of 12 credits. Doctoral students in College and University Administration, 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.

**978A. *Independent Research in Higher Education Administration***

*Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 6 credits. Doctoral students in College and University Administration.*

Supervised and guided in-depth readings in literature and research specific to higher education administration which lead to the development of materials such as position papers, articles for publication, and grant and dissertation proposals.

**982. *Seminars in Administration and Curriculum***

*Fall, Winter, Spring, Summer. 1 to 9 credits. May reenroll for a maximum of 15 credits. Approval of department.*

Seminars in the various fields of emphasis.

**983. *Readings and Independent Study in Educational Administration***

*Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 15 credits. Approval of department.*

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

**984. *Laboratory and Field Experience in Educational Administration***

*Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 15 credits. Approval of department.*

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

**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

**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. 3(3-0) E E 300, MTH 214.*
Sinusoidal steady state response. Average power and rms concepts, complex frequency response. 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.*
Electromagnetic fields; EM sources, vector potential, magnetic media, inductance; energy storage time varying fields, and Maxwell's equations; potential theory and boundary value problems.

*307. Electromagnetic Fields and Waves III*
*Spring, Summer. 3(3-0) E E 306.*
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*
*Fall, Spring. 1(0-3) E E 307 or 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.

*311. Machine Organization and Assembly Language Programming*
*Fall, Winter, Spring. 4(3-3) CPS 252, MTH 214. Interdepartmental with and administered by the Department of Computer Science.*
Machine structure, registers and operations. Subprogram linkage. Discrimination of translator, loader and execution tasks. Programming in assembly language.

*320. Electromechanical Energy Conversion*
*Fall, Spring. 3(3-0) E E 301, E E 306.*
Review of electromagnetics, three phase power, transformers, electromechanical energy conversion, basic concepts of rotating machines, alternating current machines.

*330. Digital Logic Fundamentals*
*(E E 230.) Fall, Winter, Spring, Summer. 4(4-0) CPS 252. Interdepartmental with the Department of Computer Science.*
Boolean algebra, combinational logic and minimization, sequential system fundamentals and components; arithmetic operations and devices; memory devices and ensembles; digital integrated circuits; practical engineering design problems.

*345. Introduction to Electronic Instrumentation Systems*
*Fall, Winter. 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.

*355. Deterministic Communication Systems*
*Fall, Spring. 3(3-0) E E 301, MTH 214. Interdepartmental with Systems Science.*
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.

*410. Digital Circuit Design I*
*Fall, Winter, Spring. 4(3-3) E E 330, E E 302.*
MOS and BJT transistor models; SPICE models and simulation; logic family characteristics; latches, flip-flops; timers; memory circuits; timing diagrams; gate arrays; standard cells; microprocessors; PLAs.

*411. Digital Circuit Design II*
*Spring. 4(3-3) E E 410.*
Properties of switching algebra; combinational circuit design; fundamental-mode analysis of sequential circuits; pulse mode sequential circuits; circuit synthesis, design for testability; semi-custom circuit design.

*412. State Models, Analysis, and Simulation*
*Spring. 3(3-0) SYS 311, MTH 310, MTH 334. Interdepartmental with and administered by Systems Science.*
Vector-matrix state-space models of dynamic systems, exponential matrix, transform solutions, convolution, stability, controllability, observability, simulation, computational techniques, extensions to nonlinear systems.

*413. Analysis of Control Systems*
*(313.) Fall. 4(4-0) E E 301, E E 355. Interdepartmental with and administered by Systems Science.*
Control system characteristics, performance criteria, transient and steady-state responses, error analysis, stability, root locus and frequency response techniques. Controller design using root locus and frequency response methods.

*414. Control Systems Laboratory*
*Winter, Spring. 1(0-3) CPS 311, E E 304, SYS 413. 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.

*415. Digital Control Systems*
*Winter. 3(3-0) CPS 311, SYS 311, SYS 413. Interdepartmental with Systems Science.*
Organization of digital control systems, classical and modern techniques for the design of digital control systems. Hardware and software considerations with emphasis on microprocessor implementation.

*416. Computers in Robotics*
*Spring. 3(2-3) E E 415.*
Topics include overview of robots, sensors, homogeneous transforms, kinematics, trajectory planning, control and introduction to vision.

*418. Introduction to Computer-Aided Circuit Design*
*Fall. 3(3-0) CPS 301, 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 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.

*421. Power System Analysis*
*Spring. 3(3-0) E E 320 or concurrently.*
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.

*422. Power Electronics*
*Winter. 3(3-0) E E 302, E E 320.*
Thyristor characteristics, commutation, AC voltage controllers, single-phase and three-phase rectifier and inverter circuits, DC-to-DC converters, cycloconverters, AC and DC motor drives.

*423. Electrical Machines Laboratory*
*Spring. 1(0-3) E E 320.*
Transformers, torque, power and speed characteristics of induction, synchronous and dc machines, steady state and transient operation of machines, machine control.

*424. Computer Architecture I*
*Fall, Winter, Spring. 4(3-3) E E 330. Interdepartmental with and administered by the Department of Computer Science.*
Computer organization; control unit implementation; input-output, interrupt, and interface design; digital system simulation.

### 425. Computer Architecture II

*Winter, Spring, Summer. 4(2-6) CPS 424. Interdepartmental with and administered by the Department of Computer Science.*

Microprogrammed control; pipelining; multiprocessing and parallel processing; fault tolerant computing. Implementation of a digital system combining simulation and hardware.

### 430. Digital Electronics

*Fall, Winter, Spring. 3(2-3) E E 230, E E 302.*

Diodes and transistors as switching elements; logic families, data conversion circuits; memory circuits; digital subsystem design.

*Approved through Summer 1989.*

### 431. Computer Interfacing

*Fall, Winter, Spring. 4(3-3) CPS 311, E E 410.*

Case study of a small computer system; I/O controller design; bus interface requirements, interrupt structure, and data transfer. Digital system design.

### 435. Microwave Circuits and Systems

*Fall. 3(3-0) E E 307.*

Waves guided by open and closed-boundary systems. Normal modes of microstrip, metallic and dielectric waveguides. Microwave cavities, devices, and circuit theory. S-parameter description of microwave devices. System applications.

### 436. Radiation and Reception 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.

### 456. Applied Probability in Communication Theory

*Fall, Winter. 3(3-0) E E 355.*

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.

### 466. Digital Filter Design

*Winter. 3(3-0) E E 355, E E 456.*

Design of digital filter algorithms and their implementation; software and hardware considerations. Applications and application driven design.

### 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. 4(4-0) E E 302; E E 305.*

Energy levels in atoms and crystals; density of states; Fermi-Dirac and Maxwell-Boltzmann statistics; transport properties of bulk materials; metal-semiconductor contacts; the p-n junction and BJT.

### 475. Electronic Devices and Circuits

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

Fabrication technology; models and characteristics of BJT's, JFET's, and MOS devices; application to linear and digital circuits.

### 476. Applications of Electronic Devices

*Spring. 3(3-0) E E 474.*

Power devices and applications; transistors, diacs, triacs, and SCR's; high frequency devices and applications; transitors; impatt, Gunn and vacuum devices; photo-devices; solar cells and LED's.

### 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.

### 478. Integrated Circuit Fabrication Laboratory

*Winter, Spring, Summer. 2(1-3) E E 474.*

Integrated circuit design and fabrication. Laboratory fabrication of diffused resistors, diodes, capacitors, and simple MOS or bipolar integrated circuits. Yields, testing, and economic considerations.

### 480. Integrated Circuits: Operational Amplifiers

*Fall, Winter. 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.

### 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.

### 812. Computer Networks

*Spring. 3(3-0) CPS 313, CPS 412, CPS 423. Interdepartmental with and administered by the Department of Computer Science.*

Data communication, baseband and broadband local area networks, logical link control, internet protocol, transport protocol, naming and addressing, interprocess communication, reliable broadcast protocol, distributed processing.

### 813. Logic Design Methodologies

*Spring. 3(3-0) CPS 423 or E E 431. Interdepartmental with the Department of Computer Science.*

Modeling and simulation of logic circuits; hardware description languages; design methodologies for logic arrays and bit-slice processors; fault tolerance, testability, computer aided design of logic circuits; automated routing algorithms.

### 815. Advanced Computer Architecture

*Fall, Winter. 3(3-0) CPS 313, CPS 423. Interdepartmental with and administered by the Department of Computer Science.*

Classification of computer systems, memory organizations, cache memory, lookahead processor, stack processor, pipeline processor, vector processing, associative processor, super computer architectures, parallel processing, performance issues, case studies.

### 816. Fault-Tolerant Computing

*Winter. 3(3-0) E E 813. Interdepartmental with the Department of Computer Science.*

Reliability evaluation; fault models and test pattern generation; design for testability; fault-tolerant design techniques; self-checking circuits and systems; system diagnosis and reconfiguration; case studies.

### 818. Introduction to Robotics

*Spring. 3(3-0) E E 415 or M E 458 or approval of department. Interdepartmental with the Department of Computer Science.*

Robot configuration and geometry. Robot drive systems, kinematics, controller design, sensors, sensor-based robots. Economic, political and social implications. Industrial application.

### 820. Electric Power Transmission System

*Spring of odd-numbered years. 4(4-0) E E 421 or approval of instructor.*

Symmetrical components, calculation of short circuit currents for symmetrical and unsymmetrical faults; methods and devices used in protection; pilot wire and carrier systems, circuit interruption, grounding.

### 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.

*824. Power System Operation and Control*

*Fall of odd-numbered years. 3(3-0) E E 421, SYS 413, E E 456 or STT 441.*

Operation planning of power systems including load flow, unit commitment, and production cost methods; on line operation and control including automatic generation control, economic dispatch, security assessment, and state estimations.

*825. Alternating Current Electrical Machines*

*Spring of even-numbered years. 3(3-0) MTH 424; E E 320 or approval of instructor.*

Analysis, modeling and design aspects of synchronous, induction, and switched reluctance machines for use in power systems stability and control, and in motion control.

*826. Advanced Linear Systems Analysis*

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

Analysis of linear continuous time and discrete time systems for both time invariant and time varying models; state space and transfer function models; transition matrices; controllability; observability; minimal realizations; stability.

*831. Active Network Synthesis*

*Winter. 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.

*832. Switched Capacitor Circuits*

*Spring of even-numbered years. 3(3-0) E E 480.*

Switched capacitor analog circuit analysis and design. Analog sampled data concepts; implementation of signal processing operations; switched capacitor filters; nonideal effects; linear and nonlinear applications.

*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.

*845. Detection and Estimation Theory*

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

Classical detection theory, hypothesis testing, decision criteria, multiple hypotheses, colored noise, detection of signals with unknown parameters, Bayes estimates, MAP, ML, LMSE, Wiener and Kalman filters, nonlinear estimation, application to communications and radar systems.

*846. Information Theory and Coding*

*Spring of even-numbered years. 3(3-0) SYS 863 or approval of instructor.*

Discrete and continuous channels. Channel capacity. Shannon's source coding and channel coding theorems. Rate distortion theory. Linear codes, Hamming, BCH, Cyclic codes. Convolutional codes. Viterbi algorithm, sequential decoding.

*847. Communication Engineering*

*Fall. 4(4-0) E E 457. 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) SYS 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 Department of Physics and Astronomy.*

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.

*857. Microprocessor-based System Design*

*Spring. 4(2-6) E E 431 or CPS 423.*

Microprocessor-based system design methodology; performance measures; single-chip computer organization alternatives; local networks of processors; applications in signal processing control and instrumentation.

*863. Analysis of Stochastic Systems*

*Winter. 3(3-0) SYS 826, STT 441, MTH 424. 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*

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

Fabrication and design of integrated circuits. Physics and chemistry of processing. Comparison of current bipolar and MOS technologies, and their limitations. VLSI design methodology and layout examples.

*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. Digital Signal Processing*

*Winter. 3(3-0) E E 456 or STT 441. Interdepartmental with Systems Science.*

Discrete time signals and systems, random discrete time signals. Basic principles of estimation theory, spectral estimation. Digital filter design techniques.

*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.

*920. Advanced Topics on Power*

*Winter. 3(3-0) E E 823 or E E 824.*

Current research topics in power system planning, operation and control. Topics may include AC/DC systems, computational methods for balanced and unbalanced systems, stability, and security.

*921. Multiprocessors and Parallel Processing*

*Fall. 3(3-0) CPS 812, CPS 815. Interdepartmental with and administered by the Department of Computer Science.*

Massively parallel processor, parallel memory, interconnection network, tightly and loosely complied multiprocessors, message-passing model, shared-memory model, operating systems, performance, parallel languages and algorithms.

*922. Advanced Computer Systems*

*Winter. 3(3-0) CPS 921, E E 813. Interdepartmental with and administered by the Department of Computer Science.*

VLSI and WSI architectures, mapping algorithms to architectures, functional programming, dataflow computer, concurrent symbolic processing and logical programming, computer architecture for artificial intelligence, recent advances in computer systems.

**925. *Control of Electrical Drives***

*Fall of even-numbered years. 3(3-0) E E 413, E E 422, E E 825.*

Current and voltage source inverter, converter and cycloconverter circuits. Pulse width modulation techniques. Models of electrical machines used in industrial drives, derivation of control algorithms. Microprocessor based control systems.

**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***

*Winter. 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***

*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.

**989. *Electrodynamics of Plasmas II***

*Winter of odd-numbered years. 3(3-0) E E 850. Interdepartmental with the Department of Physics and Astronomy.*

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.

**355. *Deterministic Communication Systems***

*(455.) Fall, Spring. 3(3-0) E E 301, MTH 214. Interdepartmental with and administered by Electrical Engineering.*

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.

**410. *Systems Methodology***

*Winter, Spring. 3(2-3) C E 370, CPS 115 or CPS 112.*

Systems analysis and design. Needs analysis. Assignment of input, state and output variables. Graphical and programmable models of systems and components. Completion of team project including verbal briefings and written final report.

**411. *Systems Project***

*Spring. 2(3-0) SYS 410.*

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.

*Approved through Fall 1988.*

**412. *State Models, Analysis, and Simulation***

*Spring. 3(3-0) SYS 311, MTH 310, MTH 334. Interdepartmental with Electrical Engineering.*

Vector-matrix state-space models of dynamic systems, exponential matrix, transform solutions, convolution, stability, controllability, observability, simulation, computational techniques, extensions to nonlinear systems.

**413. *Analysis of Control Systems***

*Fall. 4(4-0) E E 301, E E 355. Interdepartmental with Electrical Engineering.*

Control system characteristics, performance criteria, transient and steady-state responses, error analysis, stability, root locus and frequency response techniques. Controller design using root locus and frequency response methods.

**414. *Control Systems Laboratory***

*Winter, Spring. 1(0-3) CPS 311, E E 304, SYS 413. 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.

**415. *Digital Control Systems***

*Winter. 3(3-0) CPS 311, SYS 311, SYS 413. Interdepartmental with and administered by Electrical Engineering.*

Organization of digital control systems, classical and modern techniques for the design of digital control systems. Hardware and software considerations with emphasis on microprocessor implementation.

**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.

**465. *Process Optimization Methods***

*Spring. 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. Flowsheet optimization with process simulation packages.

**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.

**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. May not be used for graduate credit by Electrical Engineering and Systems Science majors except Operations Research/Systems Science. Interdepartmental with the College of Social Science.*

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 the College of Social Science.*

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.

**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, approval of instructor. Interdepartmental with Electrical Engineering.*

Analysis of linear continuous time and discrete time systems for both time invariant and time varying models; state space and transfer function models; transition matrices; controllability; observability; minimal realizations; stability.

**827. *Nonlinear Systems Analysis***

*Spring. 4(4-0) SYS 826, MTH 424.*

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

*829. Linear Multivariable Control Systems*
*Winter. 4(4-0) SYS 826, STT 441, SYS 413.*
Linear continuous time and discrete time multivariable control systems; state and output feedback; observers; eigenstructure placement; asymptotic tracking; optimal linear control; stochastic processes; Kalman filter; LQG optimal control.

*835. Static Optimization Methods*
*Summer. 4(4-0) MTH 424.*
Linear and 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 even-numbered years. 3(3-0) C E 346, STT 351 or approval of department. Interdepartmental with and administered by 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 457. 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) SYS 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) SYS 826, STT 441, MTH 424. 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. Digital Signal Processing*
*Winter. 3(3-0) E E 456 or STT 441. Interdepartmental with and administered by Electrical Engineering.*
Discrete time signals and systems, random discrete time signals. Basic principles of estimation theory, spectral estimation. Digital filter design techniques.

*899. Master's Thesis Research*
*Fall, Winter, Spring, Summer. Variable credit. Approval of department.*

*960. Nonlinear Control*
*Fall of even-numbered years. 3(3-0) SYS 827, M E 458 or E E 413. Interdepartmental with and administered by the Department of Mechanical Engineering.*
Input-output stability of feedback systems; describing function methods; relay control; stabilizing controllers; design techniques selected from variable structure, high-gain, geometric, Lyapunov-based, vibration, feedback linearization and tracking controls.

*961. Optimal Control Theory*
*Fall of odd-numbered years. 3(3-0) SYS 829, MTH 424.*
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.

*963. Dynamic System Identification*
*Winter of odd-numbered years. 3(3-0) SYS 863.*
Review of stochastic system modeling; identifiability; canonical forms; spectral factorization; least squares and maximum likelihood identification methods and their properties, consistent estimators; closed-loop system identification, recursive algorithms; experiment design.

*964. Large Scale Dynamic Systems*
*Spring of even-numbered years. 3(3-0) SYS 827, SYS 829.*
Topics will be drawn from: model reduction and aggregation; stability of interconnected systems; multiple time scale decomposition; decentralized control; hierarchical control.

*965. Adaptive Control*
*Spring of odd-numbered years. 3(3-0) SYS 827, SYS 829, SYS 963.*
Model reference adaptive control in continous time and discrete time; Lyapunov and hyperstability approaches; adaptive observers; self tuning regulators; design using pole-zero assignments, minimum variance control and LQG control.

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

## ENGINEERING EGR

### College of Engineering

*150. Engineers and the Engineering Profession*
*Spring. 3(3-0)*
Overview of the engineering profession. Historical background. Engineering specialties. Engineers at work. Professionalism and ethics. Communication skills. Future trends.

*200. Technology, Society and Public Policy*
*Winter. 3(3-0) Twelve credits from natural science or engineering. Interdepartmental with the Department of Natural Science.*
Description and analysis of certain current technologies and their consequences; exploration of avenues for assessing such consequences as an aid to formulation of public policy.

*290. Selected Topics*
*Fall, Winter, Spring, Summer. 1 to 3 credits May reenroll for a maximum of 6 credits if different topics are taken.*
Experimental course developments or special topics appropriate for freshmen and sophomores.

*344. Engineering Cooperative Education*
*Fall, Winter, Spring, Summer. Zero credits. [3 credits-See page A-1, item 3.] May reenroll for a maximum of ten terms. Employment assignment approved by College of Engineering.*
Pre-professional employment in industry and government related to student's major.

*390. Value Engineering*
*Fall. 4(4-0) Engineering Arts juniors, approval of department.*
The basis of value engineering is function, value, and a group of special techniques developed to aid in isolating and identifying problems created by our complex society and technology.

*401. Engineering and Public Policy*
*Spring. 3(3-0) Seniors or approval of department. Interdepartmental with the Department of Natural Science.*
Sociotechnical assessment of impact of technology on society, with analysis of the role of engineering and natural science in contributing to public policy formulation.

## ENGLISH ENG

### College of Arts and Letters

*091. English for Foreign Students—Structures*
*Fall, Winter, Spring, Summer. Zero credits. [3(5-0) See page A-1 item 3.] English language proficiency examination.*
Explanation and intensive practice of basic grammatical structures of English. Students are tested and then placed in small groups, from beginning to advanced, depending on their need.