951H. Field Research Methods in Education
(ED 961., T E 920., EAC 951H.)
Spring, 3(3-0)
Methods of interview, participant observation or observation for carrying on educational research.

951I. Professional Lectures in Educational Administration
(ED 978., EAC 951I.) Fall, 3(3-0)
Graduate students in Educational Administration or approval of department.
Lectures by faculty in Educational Administration in individual faculty research and service interests, exploration of recent research and other scholarly publications.

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
(ED 971, EAC 952A.) 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
(ED 972, EAC 952B.) Fall, Winter, Spring. 3 credits. May reenroll for a maximum of 27 credits. Present or past position as an educational administrator.
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
(ED 987B, EAC 960.) 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 890, EAD 881.
Educational program planning and development for organizations that serve adult populations. Alternative program planning strategies to accommodate adult learner needs, organizational resources and desired outcomes.

970A. The Law of Higher Education
(ED 980, EAC 970A.) 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
(ED 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
(ED 957., EAC 971A.) 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
(ED 958, EAC 971B.) 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 16, student flow and faculty activity analysis are major tools investigated.

971C. Evaluation of Higher Education
(ED 965C, EAC 971C.) 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
(ED 970, EAC 971D.) 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
(ED 973, EAC 973A.) 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
(ED 974, EAC 973B.) Winter. 3(3-0)
Doctoral students in Student Affairs Emphasis. Others, approval of instructor.
Study on an individual or group basis in the various fields of emphasis.

974. Laboratory and Field Experience in Administration and Curriculum
(ED 984, EAC 984.) Fall, Winter, Spring. 1 to 6 credits. May reenroll for a maximum of 15 credits. Approval of department.
Supervised advanced graduate practicum, observation, internships, and externships in the various areas of emphasis.

979A. Independent Research in Higher Education Administration
(ED 990, EAC 979A.) Fall, Winter, Spring. 1 to 6 credits. May reenroll for a maximum of 15 credits. Approval of department.
Supervised and guided in-depth readings in literature and research specific to higher education administration which lead to the development of material such as a position paper, articles for publication, and grant and dissertation proposals.

999. Doctoral Dissertation Research
(ED 999, EAC 999.) Fall, Winter, Spring. Variable credit. Approval of department.

983. Readings and Independent Study in Administration and Curriculum
(ED 983., EAC 983.) Fall. Winter, Spring. 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.

985. Seminar in Administration and Curriculum
(ED 992., EAC 992.) Fall, Winter, Spring. 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.

976A. Doctoral Internship in College and University Administration
(ED 991, EAC 976A.) Fall, Winter, Spring. 3(0-9) May reenroll for a maximum of 12 credits. Doctoral students in College and University Administration, approval of instructor.
Supervised internships 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.

977A. Elective Internship in Higher Education Administration
(ED 993, EAC 977A.) Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 15 credits. Approval of department.
Supervised in-depth readings in literature and research specific to higher education administration which lead to the development of materials such as a position paper, articles for publication, and grant and dissertation proposals.

977B. Seminar: Continuing Education in Higher Education Institutions
(ED 987B, EAC 960.) 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.

977C. Seminar: Continuing Education in Higher Education Institutions
(ED 987B, EAC 960.) 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.

977D. Seminar: Continuing Education in Higher Education Institutions
(ED 987B, EAC 960.) 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.

982. Seminar: Continuing Education in Higher Education Institutions
(ED 987B, EAC 960.) 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.

983. Seminar: Continuing Education in Higher Education Institutions
(ED 987B, EAC 960.) 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.

984. Seminar: Continuing Education in Higher Education Institutions
(ED 987B, EAC 960.) 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.

985. Seminar: Continuing Education in Higher Education Institutions
(ED 987B, EAC 960.) 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.

999. Seminar: Continuing Education in Higher Education Institutions
(ED 987B, EAC 960.) 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.
231. Computer Organization and Usage
Fall, Winter, Spring. 4(4-0) E E 230.
Computer structure and machine language; macros; addressing techniques; computer bus; program segmentation and linkage; microcomputer case study; survey of applications in science and engineering.

300. Electric Circuits I
Fall, Winter. 4(4-0) MTH 112.

301. Electric Circuits II
Winter, Spring. 4(4-0) E E 300, MTH 214.

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 310 and E E 301. Computer-aided circuit analysis and design.

304. Electronics Laboratory II
Fall. 1(0-3) E E 302.

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, dielectric media, capacitance, and energy storage. Boundary value problems for electrostatic fields.

306. Electromagnetic Fields and Waves II
Winter, Spring. 4(4-0) E E 305.
Magnetostatic fields; EM sources, vector potential, magnetic media, inductance, and energy storage, time-varying fields and Maxwell’s equations; potential theory and boundary-value problems. Energy conservation and conversion.

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, 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. 3(3-0) PHY 258.
Microwave measurements; passive and active components; operational amplifiers; switching devices, equivalent circuits; transducers; signal conditioning; recording; data management; basic elements of control.

355. Deterministic Communication Systems
(455.) 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.

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, conversion, 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
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) E E 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.

418. Introduction to Computer-Aided Circuit Design
Fall. 3(3-0) CPS 100, 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 395 or approval of department, MTH 215. Interdepartmental with and administered by Physics.
Concepts of electronics relative to those 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(3-3) E E 301, E E 306.
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 307, 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
Diodes and transistors as switching elements; logic families, data conversion circuits; memory circuits; digital subsystem design.

431. Computer Interfacing
Fall, Winter, Spring. 4(3-3) E E 321; E E 430.
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.

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 antenna radiation; 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. Applied Probability in Communication Theory
Fall, Winter. 3(3-0) E E 355.
497. Statistical Communication Systems
Spring. 3(3-0) E E 456; E E 467 currently.
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.

498. Communications Laboratory
Spring. 1(0-3) E E 456; E E 457 currently.
Experimental investigations on communication theory and information transmission topics from E E 455, E E 456, and E E 457.

494. 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 495 and SYS 495 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 432. Interdepartmental with the Department of Computer Science.
Number systems; fast two-operand 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.

812. Computer Networks
Spring. 3(3-0) CPS 412. Interdepartmental with and administered by the Department of Computer Science.
Network architecture model, routing and congestion control, satellite and radio networks, local computer networks, virtual terminal and file transfer protocols, network security, transport and session protocols, 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. Architecture of Computational Systems
Winter. 3(3-0) CPS 423. Interdepartmental with and administered by the Department of Computer Science.
Overview of computer system organization; theoretical constructs of computer systems; processors; control units; memory; interconnection networks.

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.

822. Symmetrical Components
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 practices.

823. Power System Stability and Control
Fall of even-numbered years. 3(3-0)
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.
847. Communication Engineering
Fall. 4(4-0) E E 456 or approval of instructor. Interdepartmental with Systems Science.

848. Communication Theory
Spring. 3(3-0) E E 847, E E 880, E E 883. Interdepartmental with Systems Science.

849. Microwave Electronics
Spring. 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 445; 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.

851. Microprocessor-based System Design
Spring. 3(3-0) E E 431 or CPS 423.
Microprocessor-based system design methodology; performance measures; single-chip computer organization alternatives; local network of processors; applications in signal processing control and instrumentation.

852. 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.

853. 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.

854. Physical Electronics
Fall. 4(4-0) Approval of department.

855. 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.

856. 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. Emphasis is on performance limitations of semiconductor power devices due to voltage, temperature and power considerations.

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

858. General Automata Theory I
Fall of odd-numbered years. 3(3-0) E E 423 or SYS 827 or approval of department. Interdepartmental with and administered by the Department of Computer Science.
Characterization of programs and programs as automata; mathematical decomposition of finite automata.

859. Advanced Computer Systems I
Fall. 3(3-0) Two graduate level courses in computer system design (hardware or software), 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.

860. Advanced Computer Systems II
Winter. 3(3-0) CPS 821. 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.

861. Antenna Theory I
Winter. 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.

862. Antenna Theory II
Spring of even-numbered years. 3(3-0) E E 826.
Radiation by equivalent aperture fields, aperture antennas, slot antennas, horn and reflector antennas, full aperture dependent antennas; pattern theory; scattering from various objects.

863. Advanced Topics in Electromagnetics
Winter. 3 to 4 credits. May reenroll for a maximum of 4 credits. E E 850 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.

864. 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.

865. 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 research devices and areas of current interest. Examples are photovoltaic, amorphous semiconductor, and piezoelectric devices.

866. 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.

867. 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.

868. 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 Zeeeman lasers, recent developments and applications.

869. 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.

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

871. Semiconductor Devices
Winter. 3(3-0) MTH 214.
Descriptive R & D of semiconductors and devices. Radial and planar effects, minority carrier transport, minority carrier devices, applications of semiconductors.

872. Diode Lasers
Spring. 3(3-0) MTH 301.
Advanced study of diode lasers and their applications, including laser spectroscopy, laser communication, laser printing, and optoelectronics.

873. Microwave Solid-State Devices
Winter. 3(3-0) MTH 301.
Advanced study of microwave solid-state devices, including diode lasers, laser spectroscopy, laser communication, laser printing, and optoelectronics.

874. Diode Lasers
Fall. 3(3-0) MTH 301.
Advanced study of diode lasers and their applications, including laser spectroscopy, laser communication, laser printing, and optoelectronics.

875. Microwave Solid-State Devices
Winter. 3(3-0) MTH 301.
Advanced study of microwave solid-state devices, including diode lasers, laser spectroscopy, laser communication, laser printing, and optoelectronics.

876. Microwave Solid-State Devices
Spring. 3(3-0) MTH 301.
Advanced study of microwave solid-state devices, including diode lasers, laser spectroscopy, laser communication, laser printing, and optoelectronics.

877. Microwave Solid-State Devices
Fall. 3(3-0) MTH 301.
Advanced study of microwave solid-state devices, including diode lasers, laser spectroscopy, laser communication, laser printing, and optoelectronics.

878. Microwave Solid-State Devices
Winter. 3(3-0) MTH 301.
Advanced study of microwave solid-state devices, including diode lasers, laser spectroscopy, laser communication, laser printing, and optoelectronics.

879. Microwave Solid-State Devices
Spring. 3(3-0) MTH 301.
Advanced study of microwave solid-state devices, including diode lasers, laser spectroscopy, laser communication, laser printing, and optoelectronics.

880. Microwave Solid-State Devices
Fall. 3(3-0) MTH 301.
Advanced study of microwave solid-state devices, including diode lasers, laser spectroscopy, laser communication, laser printing, and optoelectronics.

881. Microwave Solid-State Devices
Winter. 3(3-0) MTH 301.
Advanced study of microwave solid-state devices, including diode lasers, laser spectroscopy, laser communication, laser printing, and optoelectronics.

882. Microwave Solid-State Devices
Spring. 3(3-0) MTH 301.
Advanced study of microwave solid-state devices, including diode lasers, laser spectroscopy, laser communication, laser printing, and optoelectronics.

883. Microwave Solid-State Devices
Fall. 3(3-0) MTH 301.
Advanced study of microwave solid-state devices, including diode lasers, laser spectroscopy, laser communication, laser printing, and optoelectronics.

884. Microwave Solid-State Devices
Winter. 3(3-0) MTH 301.
Advanced study of microwave solid-state devices, including diode lasers, laser spectroscopy, laser communication, laser printing, and optoelectronics.

885. Microwave Solid-State Devices
Spring. 3(3-0) MTH 301.
Advanced study of microwave solid-state devices, including diode lasers, laser spectroscopy, laser communication, laser printing, and optoelectronics.

886. Microwave Solid-State Devices
Fall. 3(3-0) MTH 301.
Advanced study of microwave solid-state devices, including diode lasers, laser spectroscopy, laser communication, laser printing, and optoelectronics.

887. Microwave Solid-State Devices
Winter. 3(3-0) MTH 301.
Advanced study of microwave solid-state devices, including diode lasers, laser spectroscopy, laser communication, laser printing, and optoelectronics.

888. Microwave Solid-State Devices
Spring. 3(3-0) MTH 301.
Advanced study of microwave solid-state devices, including diode lasers, laser spectroscopy, laser communication, laser printing, and optoelectronics.
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.
The systems approach in multidisciplinary large scale problem solving. The development of useful system analysis tools; systems design; feasibility study; computer simulation for feasibility evaluation.

411. Systems Project
Spring. 2(3-4) 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.

412. State Models, Analysis, and Simulation
Spring. 3(3-0) STS 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
(313.) Fall. 4(4-0) E E 301, E E 335. 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
(464.) Winter. Spring. 1(0-3) E E 211, 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) E E 231, 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 analysis of behavior through numerical solutions.

445. Process Optimization Methods
Spring. 3(3-0) MTH 320. 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.

495. Independent Study
Fall, Winter, Spring, Summer. 1 to 3 credits. May enroll for a maximum of 6 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.

501. Special Problems
Fall, Winter, Spring, Summer. 1 to 4 credits. May enroll for a maximum of 5 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 System 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 210, SYS 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.

813. System Project
Spring. 3(3-6) SYS 811. Interdepartmental with the College of Social Science.
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
Summer. 4(4-0) MTH 213, MG 834 or CHE 485. Students may not receive credit for both SYS 835 and MG 835.

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 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 456 or approval of instructor. Interdepartmental with and administered by Electrical Engineering.

848. Communication Theory
Spring. 3(3-0) E E 847, E E 880, E E 883. Interdepartmental with and administered by Electrical Engineering.
851. **Modeling of Engineering Systems I**  
Winter. 3(3-0) M E 455 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. 

863. **Analysis of Stochastic Systems**  
Winter. 3(3-0) E E 410; 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 8 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 496. 
Optimal control, performance measures, principles of optimality, dynamic programming, Hamilton-Jacobi-Bellman equation, variational approach, constrained extremum, Pontryagin principle, necessary conditions, solution techniques, singular cases. 

962. **Computational Techniques for Optimal Control**  
Winter of odd-numbered years. 3(3-0) SYS 861. 
Computational methods of optimal controls, steepest descent, variation of extremals, quasi-linearization, 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. 

**ENGINEERING**  

**ENGLISH**  

**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. 

092. **English for Foreign Students—Speaking and Listening**  
Fall, Winter, Spring, Summer. Zero credits. [3(5-0) See page A-1 item 3.] English language proficiency examination. 
Intensive speaking and listening practice of spoken English in small groups (determined by proficiency). For beginners, practice is largely drill. Advanced groups use drill, drills, discussion, and practical conversations. 

093. **English for Foreign Students—Language Laboratory**  
Fall, Winter, Spring, Summer. Zero credits. [3(5-0) See page A-1 item 3.] English language proficiency examination. 
Language laboratory practice in small groups (determined by proficiency). Beginners review and supplement ENG 991, ENG 992. Advanced groups use carefully prepared lectures, speeches, and presentations to practice structures and vocabulary. 

094. **English for Foreign Students—Reading**  
Fall, Winter, Spring, Summer. Zero credits. [3(5-0) See page A-1 item 3.] English language proficiency examination. 
Intensive and extensive reading in small groups (determined by proficiency). Beginners emphasize vocabulary development and practice in basic structures. Advanced classes include reading skills, wider reading, and specialized vocabulary. 

095. **English for Foreign Students—Writing**  
Fall, Winter, Spring, Summer. Zero credits. [3(5-0) See page A-1 item 3.] English language proficiency examination. 
Frequent controlled and free writing in small groups to reduce errors and practice using structures and vocabulary to express ideas. Advanced classes include writing styles used in academic course work. 

101. **Responses Through Writing**  
Fall. 4(4-0) Arts and Letters Freshmen only. Students must enroll in and complete ENG 102 satisfactorily to make a substitution for the American Thought and Language requirement. 
A writing workshop that concentrates on the students' personal writing voice and on their responses to the things, people, and institutions central to their experience. 

102. **Writing and Composing**  
Winter. 5(5-0) ENG 101: Arts and Letters Freshmen only. A continuation of ENG 101 that develops the emphases of ENG 101 and encourages students to write in more public and objective forms—narrative, critical analysis, and issue-oriented essays. 

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