960. Counseling Theories
Winter, Summer. 3(3-0) Approval of instructor.
Survey of counseling theories and research with emphasis on current issues which have implications for counseling practice or for counselor education.

965A. Psychometric Theory
Spring. 3(3-0) 865, 969B.
Advanced theoretical aspects and derivation of formulas involved in reliability, validity, item analysis, weighting and differential prediction, sampling and scope construction, and the relation of item characteristics to test statistics.

965B. Problems of Educational Measurement
Fall, Winter. 3(3-0) 865, approval of department.
Advanced consideration of the logical and philosophical bases of educational measurement. Theory of test planning and development and evaluation. Problems of test administration and scoring. Issues in test use.

965C. Evaluation of Higher Education
Spring. 3(3-0) 869.
Ways in which evaluation takes place in higher education: course examinations, grading, comparative examinations, teacher evaluation, institutional evaluation, state surveys, and regional and national studies of higher education problems.

967. Advanced Research
Fall, Winter. 3(3-0) 867, 969.
Principles and techniques in survey research with limited consideration of content analysis and observational studies. Sampling, instrumentation, data collection, and data analysis.

969. Quantitative Methods in Educational Research
B. Advanced Quantitative Methods in Educational Research
Fall, Winter, Summer. 4(3-2) or 969B.
Approval of department.
Critical review of research and literature in counseling and personnel services.

973. College Student Personnel Administration I
Fall. 3(3-0) Approval of department.
Emphasis on planning, organization, financing, research, evaluation and administration for programs and services which exist principally to serve individual student needs: counseling; orientation, health, placement, financial aids, etc.

ELECTRICAL ENGINEERING AND SYSTEMS SCIENCE*

College of Engineering

Electrical Engineering

275. Consumer Electronics
Fall, Winter, Spring. 3(3-0)
Electronic circuit components and devices; their operation in transmitters, receivers, sterilizers, etc. Electronic measurements, magnetic recording, speaker systems, and other topics will be considered.

305. Electromagnetic Fields and Waves I
Fall, Winter. 3(3-0) PHY 215
Introduction to oscillatory fields: EM sources, scalar potential, Poisson’s and Laplace’s equations, dielectric media, capacitance, and energy storage. Boundary value problems for electromagnetic fields.

306. Electromagnetic Fields and Waves II
Winter, Spring. 3(3-0) 305.
Magnetostatic fields; EM sources, vector potential, magnetic media, inductance, and energy storage. Time–varying fields and Maxwell’s equations; energy conservation, potential theory, and radiation concepts.

307. Electromagnetic Fields and Waves III
Spring, Summer. 3(3-0) 306; 308 concurrently.
Application of Maxwell’s equations: radiation, propagation, reflection, and power flow of plane EM waves; EM boundary value problems. Transmission line theory; transient and steady state waves, standing and traveling waves, reflections and standing-wave ratios.

*Effective March 1, 1969.
308. Fields and Waves Laboratory
Spring, Summer. 1(0-3) 306; 307 concurrently.
Experimental investigation of charged particle motion in EM fields, dielectric and magnetic properties and materials, probing of currents and charges, and propagation of transient and steady-state waves. Digital computer solutions for EM field and wave problems.

311. Fundamentals of System Modeling
Fall, Winter, 3(3-0) MTH 334; PHY 388. System measurement, signal representations, mathematical models for systems of lumped physical components, topological equations for electrical networks, linear graph theory and its application to modeling electrical, mechanical, hydraulic, and other systems.

312. Analysis of Linear Systems
Winter, Spring, 3(3-0) 311. State models for general systems; numerical and analytical solutions.

313. Analysis of Large Scale Systems
Spring, Summer, 3(3-0) 312. Stability, pulse and frequency response characteristics, analysis by Laplace and Z transforms, subassemblies of multi-terminal components.

321. Analog and Digital Computer-aided Design
Fall, Winter. 3(3-0) 321 concurrently. Numerical solution of electrical systems problems, component modeling by digital computer, analog computer simulation.

345. Introduction to Electronic Instrumentation Systems
Fall, Winter. 4(3-3) PHY 288. Basic electronic concepts: passive active components; operational amplifiers; switching devices, equivalent circuits; transducers; signal conditioning; recording; data management; basic elements of control.

374. Electronics I

375. Electronics II
Winter, Spring. 4(4-0) 374. Volt-ampere characteristics of the transistor. Voltage, current and power amplification. Stability and transient effects. Oscillators, operational amplifiers.

376. Electronics III
Spring, Summer. 3(3-0) 375. Boolean algebra and logic circuits. Design, analysis, and evaluation of monostable, astable and bistable multi-vibrator circuits, logic circuits and systems. Aspects of reliability.

384. Electronics Laboratory I
Winter. 1(0-3) 374 concurrently. Experimental and measurement procedures, as appropriate to topics covered in 374.

386. Electronics Laboratory II
Spring, Summer. 1(0-3) 376 concurrently. Experimental investigation of topics covered in 375 and 376. Computer-aided analysis and design of electronic circuits.

400. Current Topics in Electrical Engineering
Winter. 1(0-3) May re-enroll for a maximum of 3 credits. Approval of department. Topics include communication systems, instrumentation systems and data management, advanced laboratory techniques, modeling, circuit design, computer analysis.

403. Special Problems
Fall, Winter, Spring, Summer. 1 to 4 credits. Approval of department. Investigation of a topic in electrical circuits or systems compatible with the student's prerequisites, interest, and ability.

415. Control Systems
Fall. 3(3-0) 415. Use of computer for analysis and simulation of control systems, design of control systems using digital computer, use of digital computer for analysis of control systems.

416. Control System Design
Winter. 3(3-0) 415 concurrently. Realization of linear controllers, consistent models for plant and computer monitoring, algorithms for digital control, organization of digital controllers.

418. Introduction to Network Synthesis

419. Physical Phenomena and Electronic Instrumentation I
Winter. 4(3-3) PHY 289 or 293; MTH 215. Laboratory and computer-aided analysis of electronic phenomena. Nuclear radiation detectors, photometers, and magnetometers are examples of specific topics covered.

435. Guided Transmission Systems
Fall. 3(3-0) 308. Electric circuit theory from EM field theory. Guided wave theory: normal modes, propagation characteristics, power transport, wave impedance, traveling and standing waves, rectangular and circular waveguides, electromagnetic resonators, and Q factors.

436. Microwave Networks and Antennas

437. Microwave Electronics and Plasma
Spring. 3(3-0) 436; 439 concurrently. Microwave electronics and plasma. Electron dynamics; field-particle interactions; space-charge waves; cyclotron waves; klystron; magnetron; traveling-wave amplifier; quadrupole amplifier; microwave solid-state devices; gas discharges; plasma; waves in plasma.

438. Transmission and Radiation Laboratory
Winter. 1(0-3) 435; 436 concurrently. Microwave transmission and radiation laboratory. Measurement of frequency, wavelength, standing waves, impedance, and power. Experiments on transmission lines, waveguides, cavities, resonators, microwave circuits, and circuit and radiation properties of antennas.

439. Microwave Electronics and Plasma Laboratory
Spring. 3(3-0) 438; 437 concurrently. Experimental investigations on topics from 437. Laboratory experiments on klystron characteristics, traveling wave amplifier, microwave semiconductor oscillator, plasma measurements, and plasma-field interactions.

455. Deterministic Communication Systems
Fall. 3(3-0) 374 or approval of department. Communication systems. Representation of signals in time and frequency domains. Processing of signals by linear, simple nonlinear and time-variant systems. Linear and nonlinear, analog and digital modulation and demodulation; for example, AM, FM, PCM.

456. Applied Probability in Communication Theory
Winter. 3(3-0) 455 or approval of department. Probability theory as applied in the study of communication systems. Representation of random signals and noise as stochastic processes. Autocorrelation and spectral density.

457. Introduction to Statistical Communication Theory
Spring. 3(3-0) 456; 467 concurrently. Representation, processing and filtering of random signals. Performance of analog, linear and nonlinear modulation systems with noise. Optimal digital communication systems.

460. Introduction to Electromagnetics

466. Control System Laboratory
Winter. 1(0-3) 415; 416 concurrently. Experiments in control of processes with a digital controller. Simulation of control systems.

467. Communication Theory Laboratory
Spring. 1(0-3) 456; 457 concurrently. Experimental investigations on communication theory and information transmission topics from 435, 436, and 457.

474. Physical Properties of Electronic Devices
475. Physical Properties of Electronic Devices II
Winter. 3(3-0) 474.

476. Physical Properties of Electronic Devices III
Spring. 3(3-0) 475.
Continuation of topics covered in 475. Aspects of integrated-circuit techniques.

484. Electronic Devices Laboratory I
Fall. 1(0-3) 474 concurrently.

801. Special Problems
Fall, Winter, Spring, Summer. 1 to 4 credits. Approval of department. Investigation of a topic in electrical engineering compatible with the student's prerequisites, interest, and ability.

811. Noise and Fluctuation Phenomena
Spring of even-numbered years; Summer of odd-numbered years. 3(3-0) Approval of department.
Nyquist formulation of thermal noise; noise phenomena associated with electron tubes, transistors, beam and parametric devices, amplifiers, mixers, and detectors; techniques and equipment for noise measurements.

816. Quantum Electronics
Fall. 3(3-0) Approval of department.
Quantized wave motion; Hamiltonian function and operator; hydrogen atom and energy states; transition probabilities; spontaneous and induced transitions; physical statistics; transport phenomena; band theory applied to conductors, semiconductors, and insulators.

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

819. Electrical Properties of Materials II
Spring of odd-numbered years. 3(3-0)
Temperature and frequency effects on conduction, dielectric constant, and dielectric loss; temperature, frequency, and bias effects on the behavior of ferrite materials; stimulated emission and absorption in materials.

831. Foundations of Network Synthesis
Fall. 3(3-0) Approval of department.
One-port networks; RL, RC, LC and RLC networks; driving point inadmittance; positive real properties; realization procedures.

832. Filter Synthesis I
Winter. 3(3-0) 831.
Two-port LC networks: transmission characteristics; filter design techniques based on image parameters; Cauer filters.

833. Filter Synthesis II
Spring. 3(3-0) 832.
Scattering parameters; Butterworth, Chebyshev, and elliptic filters; phase equalizers synthesis based on insertion functions.

835. Electromagnetic Theory I
Fall. 3(3-0) Approval of department.
Physical concepts and mathematical solution of Maxwell's equations; boundary conditions; force and energy equations; potential equations; Green's function; wave equations; radiation and propagation of electromagnetic waves.

836. Electromagnetic Theory II
Winter. 3(3-0) 835.
Formulation of electromagnetic theory from viewpoint of electromagnetic theory; calculation of impedance; propagation of electromagnetic wave in isotropic and anisotropic media; skin effects; boundary value problems.

845. Mathematical Models for Random Phenomena
Fall, Summer. 3(3-0) Approval of department.
Generation of mathematical models that employ probabilistic notions to describe control, communication, and related systems, with emphasis on distributions of random variables, conditioning, and properties of random sequences.

846. Analysis of Random Time Functions
Fall, Winter. 3(3-0) 845.
Mathematical models for time-dependent random phenomena; properties of correlation functions and spectral densities; stationarity and ergodicity; response of linear systems to random inputs; introduction to applied harmonic analysis.

847. Communication Systems
Winter, Spring. 3(3-0) 846.
Comparative analysis of modulation systems; optimal relative bandwidth and signal-to-noise ratio; telemetry and radar systems.

848. Physical Electronics
Fall. 3(3-0) Approval of department.
Types of electron emission; electron motion in electromagnetic fields; beam focusing; longitudinal and transverse beam waves; concepts of interaction between electrons and fields; basic principle of parametric electronics.

849. Microwave Electronics
Winter. 3(3-0) 835, 845.
Principles of microwave generators, including klystrons, magnetrons, traveling-wave tubes and particle accelerators; non-linear electron-wave interactions; crossed-field devices; solid state microwave electronics.

850. Ionized Gases
Spring. 3(3-0) 835 or PHY 448.
Interdepartmental with the Astronomy and Physics Department.
Elastic collision processes; Boltzmann equation; moment equations; basic plasma phenomena; motion of a charged particle in electrical and magnetic field; individual and collective charged particle behavior.

852. Semiconductor Devices
Winter. 3(3-0) 816.
Applications of the diffusion and continuity equations to semiconductor devices; delineation of the device terminal properties including transient operation.

853. Semiconductor Applications
Spring. 3(3-0) 853.
Equivalent circuits; analysis of circuit operation including high frequency effects, noise properties, nonlinear effects.

861. Bioelectric Field Theory
Spring. 3(3-0) 306.

899. Research
(EGR 599.) Fall, Winter, Spring, Summer. Variable credit. Approval of department.

911. General Automata Theory I
(981.) Fall of odd-numbered years. 3(3-0) CPS 453 or 895 or approval of department. Interdepartmental with and administered by the Computer Science Department. Characterization of machines and programs as automata; mathematical decomposition of finite automata.

912. General Automata Theory II
(982.) Winter of even-numbered years. 3(3-0) 911. Interdepartmental with and administered by the Computer Science Department. Degrees of difficulty of computation. Models of parallel computation. Iterative automata.

926. Antenna Theory I
Winter of even-numbered years. 3(3-0)
Linear antennas; cylindrical dipole antennas as radiating, receiving and scattering elements; current and charge distributions on antenna; electromagnetic fields of antennas; coupled antennas, linear antenna arrays.

927. Antenna Theory II
Spring of even-numbered years. 3(3-0) 926.
Microwave antennas; slot antennas; slot waveguide array; horn and reflector-type antennas; frequency independent antennas; pattern theory.

928. Microwave Laboratory
Summer of even-numbered years. 3(2-3) 837, 927, 928.
Experiments on transmission line systems; scattering measurements; antenna measurements; interaction of electromagnetic waves with plasmas; radiation in plasmas; experiments on electron tubes and on lasers.

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

A-53
946. Extraction of Signals from Noise
Winter of odd-numbered years. 3(3-0)

Auto-correlation and cross-correlation in detecting signals in noise; application of decision theory to the detection problem; measurement of message characteristics in noise.

947. Space Communications
Spring of odd-numbered years. 3(3-0)

Communication theory and switching theory applied to the study of communication in space; rate of information and error probability in pulse modulation systems for long distance communications.

955. Microelectronics I
Fall of odd-numbered years. 3(3-0)

Basic physical principles underlying the operation, design, and fabrication of microelectronic devices.

956. Microelectronics II
Winter of even-numbered years. 3(3-0)

Miniaturized components; thin-film networks; solid-state circuits and operational limitations.

957. Semiconductor Switching Circuits
Spring of even-numbered years. 3(3-2) or approval of department.

Switching design considerations; theory and application of device characteristics in switching circuits. Laboratory experiments using transistors and microcircuits.

975. Quantum Electromagnetics
Winter of odd-numbered years. 3(3-0)

Tensors; four-vector formulation of classical electromagnetics; relativistic electromagnetics; Lagrangian and Hamiltonian—classical and relativistic; Schrodinger's equation—classical and relativistic; quantization of wave fields, hydrogen atoms.

976. Lasers and Masers
Spring of odd-numbered years. 3(3-0)

Coherence, emission, absorption and amplification of radiation; energy levels for optically active materials; threshold, bandwidth, excitation modes and other operating characteristics; applications and recent developments.

991. Electromagnetic Wave Propagation II
Spring of odd-numbered years. 3(3-0)

Propagation in monotonically stratified media, propagation in turbulent media (scattering), propagation in stratified media, propagation in quasi-periodic media, Brillouin scattering, pulses in inhomogeneous media, propagation in moving media, complex Doppler effect, coupling between Maxwell equations and continuum equations, depolarization of EM waves.

999. Research
(EGR 899.) Fall, Winter, Spring, Summer. Variable credit. Approval of department.

Systems Science

150. Introduction to Environmental Systems
Fall. 3(3-0) Interdepartmental with the Engineering Department.

Basic systems concepts presented in a nonmathematical manner. Application to selected ecological topics, e.g., energy, water quality, food production, population dynamics. Interactive models provide opportunity for students to play decision-making role.

404. Biological and Ecological Concepts for Engineers and Mathematicians
Winter. 3(3-0) Approval of department. Interdepartmental with and administered by the Zoology Department.

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) 150, MTH 113, CPS 110 or 120. Interdepartmental with the Engineering Department.

The systems approach in multidisciplinary large scale problem solving. Development of useful system analysis tools; systems design; feasibility study; computer simulation for feasibility evaluation.

411. Systems Project
Spring. 3(3-0) 410. Interdepartmental with the Engineering Department.

Completion of a systems study initiated in 410. The project may involve the design of hardware, simulation of a solution to an interdisciplinary problem, or development of a solution concept.

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
Fall, Spring. 3(3-0) MTH 215, knowledge of linear algebra, interdepartmental with and administered by the Chemical Engineering Department.

Methods for determining optimum design and operating policies of systems of varying complexity. Includes classical methods, mathematical programming and modern methods.
843. Ecosystem Analysis, Design and Management
Spring. 3(3-0) 442 or 20L 404.
Interdepartmental with the Zoology Department.

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

847. Analysis of Stochastic Systems
Spring. 3(3-0) E E 846.
Equilibrium properties of non-stationary random processes; problems or estimation, filtering and prediction; sequential and recursive decision schemes; applications of random process theory to system modeling.

888. Hybrid Computation
Spring. 3(3-0) Approval of department.

Hybrid programming techniques, applications in simulation design, control and optimization.

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

961. Optimal Control Theory I
Fall. 3(3-0) 827, 828 or approval of department. MTH 105.

Formulation of the general control problem; controllability, observability and normality in discrete-state and continuous-state systems; performance functionals; typical control problems.

962. Optimal Control Theory II
Winter. 3(3-0) 981.

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

963. Optimal Control Theory III
Spring. 3(3-0) 962 or approval of department.

Topics selected among: computational methods for optimal controls (solution of selected two-point boundary value problems); stochastic control theory; state estimation, Kalman filtering and related statistical methods; differential game theory.

965. Special Topics in Optimal Process Theory
Spring of odd-numbered years. 3(3-0) 828 or approval of department. Interdepartmental with and administered by the Chemical Engineering Department.

Continuation of 828 and special topics from the literature in non-linear, stochastic, and dynamic programming.

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

ENGINEERING EGR

College of Engineering

150. Introduction to Environmental Systems
Fall. 2(2-0) Interdepartmental with and administered by Systems Science.

Basic systems concepts presented in a non-mathematical manner. Application to selected ecological topics, e.g., energy, water quality, food production, population dynamics. Interactive models provide opportunity for students to play decision-making role.

160. Engineering Communications
Fall, Winter, Spring. 4(1-6) MTH 108 or 111 or concurrent.

Engineering graphics, a means used by engineers to communicate their ideas to others. Freehand sketching, descriptive geometry, and graphical, numerical and computer problem solutions.

181. Mechanical Drawing
Fall, Winter, Spring. 2(0-6)

Lettering and use of instruments. Orthographic projection, working drawings, machine sketching and isometric drawing.

192. Mechanical Design
Fall, Winter, Spring. 2(0-4)

Continuation of 181 with emphasis on freehand lettering and sketching, advanced working drawings.

200. Technology and Society
Winter. 3(3-0) One term of American thought and language. Interdepartmental with the Natural Science Department.

An attempt to describe and analyze portions of current technology and its interaction and undesired consequences; an exploration of avenues for assessing such consequences for future technologies.

201. Introduction to Engineering Mechanics
Winter. 4(4-0) PHT 237. Interdepartmental with and administered by the Metallurgy, Mechanics and Materials Science Department.

Laws of mechanics governing the behavior of rigid and deformable bodies emphasizing how these laws influence engineering design. Extensive use of demonstrations.

260. Machine Drawing
Fall, Winter, Spring. 3(0-6)

Advanced orthographic projection, detail, and assembly drawing, sections and conventions, tracings, illustration and other pictorial drawings of mechanical elements.

263. Structural Drawing
Winter. 3(0-6)

An engineering graphics course.

A comprehensive study of space planning relative to residential and light-commercial interiors. Building materials, fixtures, and mechanical equipment will be studied with respect towards application and installation.

267. Architectural Drafting I
Fall, Winter, Spring. 3(0-6)

House construction detailing. Analysis and drawing of typical standard details.

285. Descriptive Geometry
Fall. 3(2-2) 160, 161.

Problems involving relations of points, lines, and planes. Intersections, developments, co-planar, and non-co-planar vectors.

300. Technology and Utilization of Energy
Winter. 3(3-0) Initial course in any sequence of courses in the Department of Natural Science. Interdepartmental with and administered by the Mechanical Engineering Department.

Problems of energy technology and its impact: energy sources, conversions, waste and environmental effects, future outlook for mankind.

384. Architectural Drafting II
Winter. 3(0-6) 267.

Functional and standard procedure in the layout of floor plans in traditional and modern houses. Rendered plot plan and required details.

385. House Planning
Fall, Winter, Spring. 3(1-4)

Elementary house architecture. Drawing plans from sketches. Kitchen planning, house styles, elements of design, financing, heating, lighting.

386. Architectural Perspective Drawing
Fall. 3(0-6) Any engineering graphics course.

One-point and two-point perspective, revolved plan and measuring line methods. Pencil rendering, problems in shade and shadows. House model to scale, optional.

401. Technology Assessment
Spring. 3(0-6) Seniors or approval of department. Interdepartmental with the Natural Science Department.

Sociotechnical evaluation of impacts of proposed technologies on economic, political, and cultural aspects of society. Identification of technical strategies and social goals. Techniques of assessment.

410. Systems Methodology
Winter. 3(3-0) 150, MTH 113, CPS 110 or 120. Interdepartmental with and administered by Systems Science.

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(0-6) 410. Interdepartmental with and administered by Systems Science.

Completion of a systems study initiated in 410. The project may involve the design of hardware, simulation of a solution to an interdisciplinary problem, or development of a solution concept.

413. Architectural Drafting III
Spring. 3(0-6) 364 or 365.

Traditional and modern elevations. One- and two-point rendered perspective. Functional plans drawn in 364 or 365 required.

480. Special Problems
Fall, Winter, Spring, Summer. 1 to 4 credits. May re-enroll for a maximum of 8 credits. Approval of department.

ENGLISH ENG

College of Arts and Letters

091. English for Foreign Students—Elementary
Fall, Winter, Spring, Summer. Zero credit. (3-0 to 1325-0)†. English language proficiency examination.

Spoken structures, pattern practice, reading, writing and laboratory in the English language for foreign students on the elementary level.

†See page A-2 item 3 A-55