929. Harmonic Analysis III
Spring of odd-numbered years. 3(3-0) MTH 928.
Selected topics from Fourier analysis on compact groups, singular integrals, harmonic analysis in Rn, Hp theory in one and several variables or differentiation of integrals.

934. Advanced Group Theory I
Fall. 3(3-0) MTH 836.
Permutation groups, characters, π properties, automorphisms, lattices of subgroups, classes of infinite groups, linear groups, recent literature.

935. Advanced Group Theory II
Winter. 3(3-0) MTH 934.
Continuation of MTH 934.

936. Advanced Group Theory III
Spring. 3(3-0) MTH 935.
Continuation of MTH 935.

948. Fluid Dynamics III
Spring of odd-numbered years. 3(3-0) MTH 885.
General theory of perfect fluids including motion of incompressible fluids in two and three dimensions and applications to problems of wing profiles. Viscous and compressible fluids discussed briefly.

964. Algebraic Topology I
Fall. 3(3-0) MTH 834, MTH 862.
Simplicial and singular homotopy theory, Eilenberg-Steenrod axioms, chain complexes, cell complexes, applications to Euclidean spaces.

965. Algebraic Topology II
Winter. 3(3-0) MTH 964.
Continuation of MTH 964 including category and functor theory, general coefficient and cohomology theory.

966. Algebraic Topology III
Spring. 3(3-0) MTH 965.
Continuation of MTH 965 including homology groups of products. Eilenberg-Zilber theorems, cohomology products, differential topology.

991. Advanced Topics in Geometry
Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 36 credits. Approval of department.
Advanced topics in geometry.

992. Advanced Topics in Analysis
Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 36 credits. Approval of department.
Advanced topics in analysis.

993. Advanced Topics in Algebra
Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 36 credits. Approval of department.
Structure of rings and algebras, Lie Algebras, Jordan algebras, advanced algebraic number theory, advanced matrix theory, and advanced topics in group theory, Lattice theory.

994. Advanced Topics in Applied Mathematics
Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 36 credits. Approval of department.
Nonlinear differential equations, asymptotic theory in differential equations, existence theorem, diffraction theory, Wiener-Hopf techniques.

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

MECHANICAL ENGINEERING — M E

College of Engineering

201. The Science of Sound I: Rock, Bach and Oscillators (N)
Winter. 4(4-0) Interdepartmental with and administered by Physics.
Production, propagation, detection of sounds. Voice, hearing, scales, timbre, musical instruments. Room acoustics. Electronic reproduction and synthesis of music. Demonstrations emphasized.

303. Thermal-Fluid Phenomena
Winter. 3(3-0) MMM 201, MTH 113.
Concepts and principles used to describe, predict, or explain thermal and fluid-flow phenomena. Constraints, approximations, engineering problem solving. Application to socio-technical questions.

304. Technology and Utilization of Energy
(300.) Spring. 3(3-0) M E 303.
Problems of energy technology and its impact: energy sources, conversions, waste and environmental effects, future outlook.

311. Thermodynamics I
Fall, Winter, Spring. 3(3-0) MTH 215 or concurrently.
Zeroth, first and second laws of thermodynamics. General energy equation. Process relations. Concepts of equilibrium, reversibility, and irreversibility. Applications of these to systems describable by two independent properties.

312. Thermodynamics II
Winter, Spring. 3(3-0) M E 311.
Continuation of M E 311. Gas and vapor relations, reactive and non-reactive mixtures. Thermodynamic principle as applied to gas and vapor power and refrigeration cycles for reciprocating and turbo machinery.

320. Kinematics of Machines I
Fall, Spring, Summer. 4(3-3) MMM 306 or concurrently.
Analysis of displacement, velocity, and acceleration in mechanical linkages; cam analysis and design; analysis of spur, helical, bevel, and worm gears, including planetary systems.

332. Fluid Mechanics I
Winter, Spring. 4(3-3) M E 311; M E 351 or concurrently; MMM 306.
Fluid statics; Bernoulli equation; nondeformable control volume applied to conservation of mass, momentum and energy; derivation of differential equations of continuity and momentum; similtude.

333. Fluid Mechanics II
Fall, Spring, Summer. 4(3-3) M E 332.
Fluid flow phenomena; laminar flow; turbulent flow, pipe flow, inviscid flows; boundary layers; external flow; an introduction to compressible flow.

347. Thermosciences and Energy Systems Laboratory
Winter, Spring. 1(0-3) M E 312 or concurrently.
Properties of pure substances; first law energy balances and second law analyses applied to a pump, turbine, refrigerator and combustion process.

351. Mechanical Engineering Analysis
Fall, Winter, Spring, Summer. 3(3-0) MTH 310.
Application of analytical methods to the solution of problems encountered in mechanical engineering.

352. Introduction to Systems and Control
Winter, Spring. 4(4-0) MMM 306, E E 345.
Modeling of a variety of physical systems, using state-variable concepts. Time and frequency response of low-order linear systems. Primary applications to mechanics and hydraulics.

406. Automotive Engines
Spring. 3(3-0) M E 312.
Analysis of internal combustion engines for vehicular propulsion.

410. Thermomechanical Continua
Fall. 3(3-0) MMM 211.
Reexamination of the continuum concept in the modeling of the deformation of solids and the flow of fluids. Cartesian tensor formulation of the basic physical laws involving stress and strain.

411. Heat Transfer I
Fall, Summer. 3(3-0) M E 311.
Analysis of steady-state and transient heat conduction; numerical solutions. Radiant heat transfer; principles and applications including radiation networks. Gaseous radiation exchange.

412. Heat Transfer II
Winter, Spring, Summer. 3(3-0) M E 333, M E 411.
Natural and forced convection based on boundary layer theory. Heat transfer in fluids with phase change. Heat exchangers, mass transfer.

413. Heat Transfer Laboratory
Winter, Spring, Summer. 1(0-3) M E 411, M E 412 or concurrently.
Basic experimental practices and measurement techniques associated with the field of heat transfer. Experimental problem solving techniques as applied to heat transfer will be employed in term projects.

414. Energy Conversion
Fall. 3(3-0) M E 312.
Fundamental principles of energy conversion systems. Direct energy conversion. Thermoelectric, thermionic, nuclear, fuel cells, magnetohydrodynamic, and other methods of power generation.

415. Solar Energy Conversion
Fall. 4(4-0) M E 311 or approval of department.
Principles of solar radiation. Calculations of terrestrial difuse and direct-beam insolation. Analyses of flat-plate and focusing collectors and energy storage systems. Solar-assisted heat pumps. Photovoltaics. Biomass conversion.

416. Statistical Thermodynamics
(313.) Spring. 3(3-0) M E 311.
Kinetic theory, classical statistical mechanics, and quantum statistical mechanics. Derivation of transport coefficients. Applications of statistical mechanics.

421. Mechanical Design
Fall, Winter. 3(3-0) MMM 211.
Introduction to design, the design process, design considerations and design procedures. Application of design principles to machine elements.

422. Mechanical Design Projects
Winter, Spring. 4 credits. M E 421.
Application of design concepts, such as optimization, economics and reliability, through several projects drawn from the basic areas of mechanical engineering (thermodynamics, heat transfer, fluid and solid mechanics).

424. Dynamics of Machines
Winter. 3(3-0) M E 320.
Analysis of static and dynamic forces in mechanical linkages; balancing of rotating and reciprocating machinery; flywheel requirements, gyroscopic forces, critical speeds.

432. Aerospace Engineering I
Fall. 3(3-0) M E 332.
Fundamentals of fluid mechanics, potential flows about bodies and airfoils, compressible flow, perturbation methods, viscous flow, boundary layers, transition, turbulence, separation, aerodynamics of wings and bodies.

433. Aerospace Engineering II
Winter. 3(3-0) M E 333.
Thermodynamics and fluid mechanics will be used to study rockets, turbojets, reciprocating engines, propellors, turboprops, and turbofans; a specific propulsion system will be designed.

434. Aerospace Engineering III
Spring. 3(3-0) MMM 306.
Particle and rigid body dynamics; orbit theory; aerodynamic forces; propulsion; longitudinal, directional and lateral stability and control; range; payload; a specific vehicle will be designed.

436. Cooling Processes
Winter. 3(3-0) M E 312.
Thermodynamic principles applied to the design of cooling systems in range of normal temperatures to ultra-low cryogenic temperature conditions. Psychrometric principles as applied to air conditioning and evaporating systems.

446. Mechanical Engineering Measurements Laboratory
Fall, Winter. 2(1-3) E E 345, M E 312, M E 333, M E 352, M E 411 or concurrently.
Mechanical engineering experiments including accuracy, data reduction, and the measurement of pressure, velocity, temperature, heat flow and vibration.

455. Mechanical Vibrations
Fall, Winter, Summer. 4(4-0) MMM 306.
Oscillatory phenomena for linear systems with one and two degrees of freedom, nonlinear systems, time varying systems with deterministic excitation, and time invariant systems with nondeterministic excitations.

458. Control Theory
Winter, Spring. 4(4-0) M E 352.
Closed-loop control systems; application of transfer function analysis; design for a definite degree of stability; on-and-off controllers.

463. Computer Aided Design
Winter. 3(2-2) CPS 112, MTH 334 or M E 351, MTH 351.
Three-dimensional transformations, perspectives, contour surface layout for design and manufacturing.

464. Computer Aided Design of Dynamical Systems
Spring. 3(2-2) M E 455, M E 463 and approval of department.
Modal analysis of dynamic systems; identification of modal characteristics from input-output data; computer techniques: including graphics, eigenvalue and Fourier transform computations.

465. Optimal Design
Fall. 3(3-0) M E 351, MTH 351.
Mechanical design optimization. Computational methods in optimization: one dimensional, unconstrained and constrained optimization. Finite element analysis in optimization problems.

490. Special Topics
Fall, Winter, Spring, Summer. 1 to 4 credits. May reenroll for a maximum of 8 credits. Approval of department.
Special topics in mechanical engineering of current interest and importance.

497H. Senior Honors Research
Fall, Winter, Spring, Summer. 1 to 5 credits. May reenroll for a maximum of 9 credits. Seniors in M E Honors Program.
Independent research project with individual professor in research area of mutual interest.

498H. Senior Honors Seminar
Spring. 1(1-0) Seniors in M E Honors Program; M E 497H concurrently.
Oral presentation of individual research projects and peer evaluation.

499. Independent Study
Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 9 credits. Approval of department.

807. Random Vibration of Structural and Mechanical Systems
Spring of odd-numbered years. 3(3-0) C E 802 or M E 823, STT 351 or STT 441, or approval of department. Interdepartmental with Civil Engineering, and the Department of Metallurgy, Mechanics, and Materials Science. Administered by Civil Engineering.
Probabilistic modeling of random excitations (e.g. earthquake, aerodynamic and ocean wave loadings); response of single and multiple degree-of-freedom systems to random excitation; designing against failure; nonstationary and nonlinear problems.

810. Intermediate Heat/Mass Transfer
Fall. 4(4-0) Approval of department.
Diffusion of heat and mass in stationary and moving media. Steady-state and transient processes. Combined heat and mass transfer. Radiant heat transfer.

813. Convective Heat Transfer
Winter. 3(3-0) M E 412; MTH 421.
Analysis of convective transfer of heat, mass and momentum in boundary layers and inducted flows. Heat transfer with phase change of fluids.

814. Radiative Heat Transfer
Spring. 3(3-0) Approval of department.
Statistical mechanics and thermodynamics of radiation. Study of spectral properties. Radiative transfer in media. Selected applications.

815. Advanced Classical Thermodynamics
Fall. 3(3-0) M E 312; MTH 422 or MTH 424.
Postulational treatment of the laws of thermodynamics. Equilibrium and maximum entropy postulates. Development of formal relationships. Principles for general systems. Applications to chemical, magnetic, electric and elastic systems.

817. Conductive Heat Transfer
Fall. 3(3-0) M E 411, M E 351.
Theory of steady and unsteady heat conduction in isotropic and anisotropic media. Derivation of various describing equations and boundary conditions. Numerical methods. Nonlinear problems. Heat sources. Extended surfaces. Duhamel's integral.

823. Theory of Vibrations I
Fall. 4(4-0) M E 455. Interdepartmental with the Department of Metallurgy, Mechanics, and Materials Science.
Discrete and continous parameter systems with linear and nonlinear characteristics. Variational principles; equations of motion. Matrices, quadratic forms; self-adjoint operators; eigenvalues. Transient and random excitations. Theory developed through physical problems.

824. Theory of Vibrations II
Winter of odd-numbered years. 4(4-0) MTH 422; M E 823 or approval of department. Interdepartmental with and administered by the Department of Metallurgy, Mechanics, and Materials Science.
Vibrations of one, two, and three-dimensional models of elastic and inelastic continua. Interaction phenomena. Stability. Variational methods. Applications to aeronautics, aerospace and undersea technology.

826. Kinematics of Machines II
Fall. 3(3-0) M E 320.
Analysis and synthesis of mechanisms using complex variables. Euler-Savary equation. Polynonmial cam design. Synthesis of function generators. Computer mechanisms.

827. Machine Design III
Spring, Summer. 3(3-0) M E 421.
Strain energy method for analyzing statically indeterminate machine members, theories of failure, fatigue, use of statistics in selection of tolerances for parts in mass production. Optimum design.

828. Machine Design IV
Winter. 3(3-0) M E 421.
Application of design theory to the synthesis of complete mechnical and hydraulic systems. Stress waves due to impact loading. Critical speed.

829. Fluid Transients
Fall. 3(3-0) M E 333 or approval of department. Interdepartmental with and administered by Civil Engineering.
Application of unsteady flow concepts and wave mechanics to hydraulic engineering; method of characteristics, surges and waterhammer in piping systems; resonance phenomena.

830. Intermediate Fluid Mechanics
Fall. 3(3-0) M E 332 or C E 321. Interdepartmental with Civil Engineering.
Deformable control volumes, Navier-Stokes equations, dimensionless variables, vorticity and circulation, turbulent flow, inviscid flow, and boundary layer theory.

832. Refrigeration

Spring. 3(3-0) M E 436.

Characteristics of refrigerants; application details pertaining to comfort cooling, food refrigeration, and ultra-low temperature units; refrigeration controls, and control systems.

841. Advanced Gas Dynamics

Spring. 3(3-0) MTH 422 or MTH 424 or approval of department.

Compressible subsonic and supersonic flow, shock waves, expansion fans, inviscid equations, perturbation theory, similarity rules, methods of measurement, method of characteristics, hodograph methods.

842. Inviscid Fluids

Spring. 3(3-0) MTH 423.

Kinematics; dynamical equations; potential flows, transformations, Helmholtz flows; added masses, forces and moments; vortex motion; wave motion.

843. Turbulence

Winter, Summer. 4(4-0) MMM 810 or approval of department.

Basic equations of turbulent motions including momentum, kinetic energy, scalar contaminants, correlation and spectrum functions. Basic elements of statistical descriptions, isotroic and shear flows, phenominological theories and hot-wire anemometry.

851. Modeling of Engineering Systems I

Fall, 3(3-0) M E 458 or E E 415. Interdepartmental with Systems Science.

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 Systems Science.

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

853. Finite Dimensional Dynamical Systems

Spring. 3(3-0) M E 851 or SYS 826 or approval of department.

Transition matrices and matrix exponentials, periodicity and reducibility; controllability and observability, weighting patterns, realizations and minimal realizations, least squares theory, free and fixed endpoint problems, canonical equations, conjugate and focal points.

855. Digital Data Acquisition and Control

Winter. 3(3-0) M E 458, M E 463.

Real-time digital measurement and control programming. Analog-to-digital and digital-to-analog converters. Computer structure, binary arithmetic, boolean operations, open-loop and closed-loop control, laboratory projects.

860. Topics in Parameter Estimation

Spring. 4(4-0) May reenroll for a maximum of 8 credits when different topics are taken. STT 421 or STT 441 recommended.

Nonlinear estimation of parameters in ordinary and partial differential equations. Related concepts in probability and statistics. Least squares, maximum likelihood and other estimators. Sequential methods. Optimum experiment design. Model-building.

870. Wave Motion in Continous Media I

Winter of even-numbered years. 4(4-0) MTH 422, MMM 810 or approval of department.

Linear and nonlinear waves in bounded and unbounded media. Reflection, refraction, diffraction. Dispersion. Shock and acceleration waves. Waveguides. acoustical and optical analogies. Application to elastic, visoelastic, plastic and fluid media.

890. Special Topics

Fall, Winter, Spring, Summer. 2 to 4 credits. May reenroll for a maximum of 9 credits. Approval of department.

Special topics in mechanical engineering of current interest and importance.

899. Master's Thesis Research

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

917. Advanced Heat Conduction

Winter of even-numbered years. 3(3-0) M E 817 or CHE 826 or MTH 841.

Exact analytical techniques including use of Green's function and integral transforms; approximate numerical methods; phase change problems; ablation; inverse heat conduction problems.

925. Mechanical Engineering Problems

Fall, Winter, Spring, Summer. 1 to 5 credits. May reenroll for a maximum of 9 credits. Approval of department.

Analysis of advanced engineering problems involving design, thermodynamics, fluid dynamics, gas dynamics, space.

960. Nonlinear Control

Fall of even-numbered years. 3(3-0) SYS 827, M E 458 or E E 413. Interdepartmental with Systems Science.

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.

980. Advanced Topics in Heat Transfer

Spring. 3(3-0) M E 813, M E 814, M E 817 or approval of department.

Advanced topics in conduction, convection, radiation or phase-change heat transfer, interactive combined modes, or combined heat and mass transfer.

999. Doctoral Dissertation Research

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

MEDICAL TECHNOLOGY M T

College of Natural Science

110. Clinical Laboratory Science and Health Care Delivery

Winter. 2(2-0)

The history and definition of medical technology, its diagnostic and therapeutic role in health care delivery, and its relationship to other allied health professions.

210. Exploration of the Disciplines of the Clinical Laboratory Sciences

Fall. 2(2-0) Sophomores in medical technology.

Clinical laboratory disciplines including hematology, immunohematology, chemistry, microbiology, cytology, and histology through an examination of laboratory testing and its roles in the assessment, prevention, monitoring of health state.

211. Introduction to the Clinical Laboratory

Fall. 1(0-2) M T 210 or concurrently.

Basic laboratory techniques in clinical microbiology, immunohematology, hematology, hemostasis, clinical chemistry and clinical microscopy.

300. Foundations of Laboratory Practices

Fall. 3(3-0) Clinical Laboratory Sciences majors.

Quality assurance of clinical laboratory analysis.

400. Clinical Laboratory Sciences Educational Practices

Spring. 2(2-0) Clinical Laboratory Sciences majors, approval of Medical Technology Program.

Development and implementation of educational programs for clinical laboratory personnel. Includes scope of CLS education, administration of programs and accreditation standards.

401. Clinical Biochemistry Laboratory

(M T 301.) Spring. 1(0-3) M T 300, M T 412.

Laboratory techniques in clinical biochemistry. Emphasis on the quality assurance and clinical correlation of body fluid analysis.

410. General Pathology

(PTH 404., M T 404.) Spring. 3(3-0) ANT 316; PSL 432 or concurrently. Interdepartmental with the Department of Pathology.

Features of lethal and sublethal cell injury and inflammation and repair process. Definition of the major causes of pathologic change with a consideration of specific associated diseases.

411. Basic Histopathology

Spring. 2(1-2) ANT 420, PSL 432; M T 410 or concurrently. Interdepartmental with the Department of Pathology.

Microscopic examination of cell injury and death, inflammation and tissue repair. Pathologic tissue changes in diseases resulting from degenerative changes, abnormal metabolism, neoplasia, immunologic processes, infection, mechanical trauma and malnutrition.

412. Clinical Biochemistry

(BCH 412.) Winter. 3(3-0) BCH 401; CEM 162. Medical Technology and Clinical Laboratory Sciences majors.

A comprehensive survey of clinical biochemistry; assessment of normal and pathologic physiology.

420. Hematology

Spring, Summer. 3(3-0) BCH 401, PSL 432.

Physiology, pathophysiology and laboratory assessment of hematological states.

421. Hematology Laboratory

Spring, Summer. 1(0-2) or 2(0-4) M T 420 or concurrently.

Laboratory techniques in hematology. Normal and abnormal blood cell morphology.