*920. Harmonic Analysis I*
*Fall of even-numbered years. 3(3-0) MTH 823, MTH 862 or approval of department.*
Fourier series, mean and point-wise convergence. Fourier-Stieltjes series. Maximal functions and a.e. convergence. Conjugate functions. Interpolation of operators. Hausdorff-Young Theorems.

*924. Functional Analysis I*
*Fall of odd-numbered years. 3(3-0) MTH 826 or approval of department.*
Topological groups and topological vector spaces, metrizability, locally convex spaces, Hahn-Banach and Krein-Milman theorems, dual spaces, Banach spaces, Hilbert spaces, Banach algebras.

*925. Functional Analysis II*
*Winter of even-numbered years. 3(3-0) MTH 924 or approval of department.*
Continuation of MTH 924.

*926. Functional Analysis III*
*Spring of even-numbered years. 3(3-0) MTH 925.*
Continuation of MTH 925.

*928. Harmonic Analysis II*
*Winter of odd-numbered years. 3(3-0) MTH 920.*
Fourier transforms on Rn and R. Tempered distribution, inversion formula, Plancherel Theorem, pseudo-measures, almost-periodic functions, spectral properties, Wiener Tauberian Theorem, Paley-Wiener Theorems.

*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, $\pi$ 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.
*Approved through Fall 1990.*

*304. Technology and Utilization of Energy*
*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*

*Fall, Winter, Summer. 3(2-2) CPS 112, M E 351 or MTH 334.*

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.*

Investigation of a subject approved and supervised by a faculty member.

*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*

*Winter. 4(4-0) M E 455, MMM 801. 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*

*Spring. 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.

*825. Nonlinear Oscillations*
*Spring. 3(3-0) M E 455.*
Perturbation methods. Weakly nonlinear ordinary differential equations. Modal interaction; saturation; internal resonances; subharmonic, superharmonic combination resonances; jump phenomenon. Laboratory demonstrations.

*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) M E 333 or M E 432 or M E 830 or M E 844 or approval of department.*
Thermodynamics of fluid flow, one-dimensional compressible flow, shock waves, Prandtl-Meyer flow, one-dimensional unsteady flow, Riemann invariants, shock tube, small perturbation theory, similarity rules, method of characteristics.

*842. Inviscid Flows*
*Winter. 3(3-0) M E 830 or M E 844; MTH 423 or approval of department.*
Kinematics, dynamical equations, potential flow, singularities, vortex motion, virtual mass, flow past bodies, complex variables and conformal mapping, forces and moments.

*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.

*844. Viscous Flows*
*Fall. 3(3-0) M E 333 or M E 830 or approval of department.*
Kinematics, integral and differential conservation laws, Navier-Stokes equations, vorticity and circulation, similarity and dimensional analysis, laminar viscous flows, laminar boundary layer theory, similarity solutions, approximate methods, separation, thermal effects.

*851. Modeling of Engineering Systems I*
*Fall. 3(3-0) M E 458 or E E 415.*
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.*
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 E E 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.

*856. Optimal Design of Mechanical Systems*
*Spring. 3(3-0) MTH 334; M E 455 or MMM 402 or approval of department.*
Formulation of optimization problems with applications in mechanical and structural design. Optimal design of dynamic systems, sensitivity analysis. Computational methods in optimization.

*857. Multibody Mechanics*
*Winter. 3(3-0) MMM 801 or approval of department.*
Multibody mechanics theory and computational methods, rigid and deformable multibody kinematics and dynamics; modeling techniques, coordinate choices, automatic equation generation, solution techniques, linearization, optimization, animation.

*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) E E 827, M E 458 or E E 413. Interdepartmental with the Department of Electrical Engineering.*
Input-output stability of feedback systems; describing function methods; relay control; stabilizing controllers; design techniques selected from variable structure, high-gain, geometric, Lyapunov-based, vibration, feedback linearization and tracking controls.

*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.