885. *Fluid Dynamics II*

Winter of odd-numbered years. 3(3-0) MTH 884.

Continuation of MTH 884.

886. *Partial Differential Equations I*

Fall. 3(3-0) MTH 334, MTH 423, MTH 426.

Cauchy-Kowalewski theorem; classification, characteristics, normal forms: general theory of first order equations; potential theory.

887. *Partial Differential Equations II*

Winter. 3(3-0) MTH 886.

Elliptic type equations; Green's Neumann's and Kernel functions; boundary value problems and integral equations; hyperbolic equations, geometry of characteristics, Riemann's functions.

888. *Partial Differential Equations III*

Spring. 3(3-0) MTH 887.

Continuation of hyperbolic equations; application of functional analysis to existence theorems, theory of Leray and Schauder.

890. *Reading in Mathematics*

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

899. *Master's Thesis Research*

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

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 823, MTH 862 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.

927. *Theory of Measure and Integration*

Spring. 3(3-0) MTH 822. Interdepartmental with the Department of Statistics and Probability.

Introduction to the theory of integration over abstract spaces. Topics include: measure spaces; measurable and integrable functions; modes of convergence, theorems of Egroff, Lusin, Riesz-Fisher, Lebesgue absolute continuity, and the Radon-Nikodym theroem; product measures and Fubini's theorem. Applications to some of the classical theories of integration and summability.

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, 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.

951. *Approximation Theory I*

Fall of odd-numbered years. 3(3-0) MTH 823 or approval of department.

Tchebycheff, approximation with polynomials, rational functions and general linear families; the Uncity problem; degree of approximation; Berstein Polynomials; Remes algorithm, uniform approximation with constraints.

952. *Approximation Theory II*

Winter of even-numbered years. 3(3-0) MTH 951.

Continuation of MTH 951. Generalized methods of measuring error: Approximation in Li, and Lp norms, least-square approximation and orthogonal functions; spline functions; approximation in normed linear spaces.

953. *Approximation Theory III*

Spring of even-numbered years. 3(3-0) MTH 952.

Continuation of MTH 952.

961. *Topological Groups*

Winter of even-numbered years. 3(3-0) MTH 862.

General properties of topological groups, classical groups and Lie groups.

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. Variable credit.

992. *Advanced Topics in Analysis*

Fall, Winter, Spring, Summer. Variable credit.

993. *Advanced Topics in Algebra*

Fall, Winter, Spring, Summer. Variable credit. 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. Variable credit. 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.

Man-sound relationship. Production, propagation, detection of sounds. Voice hearing, scales, timbre, musical instruments. Room acoustics. Electronic reproduction and synthesis of music. Demonstrations emphasized.

202. *The Science of Sound II*

Spring. 3(3-0) or 4(4-0) PHY 201. Interdepartmental with Physics.

Nature, generation, and progagation of sound. Acoustical phenomenon and measurements. Storage and manipulation of sound in numerical form. Music programming.

300. *Technology and Utilization of Energy*

Winter. 3(3-0) Initial course in any sequence of courses in the Department of Natural Science.

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

303. *Thermal-Fluid Phenomena*

Spring. 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.

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.

346. Mechanical Engineering Measurements Laboratory

Winter, Spring. 2(1-3) E E 345.

Mechanical engineering experiments including accuracy, data reduction, and the measurement of pressure, velocity, temperature, heat flow and vibration.

347. Thermosciences and Energy Systems Laboratory

Fall, Spring, Summer. 2(1-3) M E 311, M E 346, 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 Anlysis

Fall, Winter, Summer. 4(4-0) CPS 120 or concurrently, MTH 310.

Application of analytical and numerical methods to the solution of problems encountered in mechanical engineering.

352. Introduction to Systems and Control

Winter, Spring. 4(4-0) PHY 288, MTH 310.

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(2-3) M E 312.

Analysis of internal combustion engines for vehicular propulsion.

407. Automotive Vehicles

Fall. 3(3-0) MMM 306.

Analysis of the propulsion, braking, steering, and suspension requirements.

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. 3(3-0) M E 333.

Natural and forced convection based on boundary layer theory. Heat transfer in fluids with phase change. Heat exchangers, mass transfer.

414. Energy Conversion

Winter. 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. 3(3-0) 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 333.

Fundamentals of fluid mechanics, potential flows about bodies and airfoils, compressible flow, perturbation methods, viscous flow, boundary layers on airfoils, transition, turbulence, separation, aerodynamics of wings and bodies.

433. Aerospace Engineering II

(417.) 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

(471.) 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.

455. Mechanical Vibrations

Fall, Winter. 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 non-deterministic 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 I

Winter. 3(2-2) CPS 120, MTH 334.

Three-dimensional transformations, perspectives, contour surface layout for design and manufacturing, an introduction to finite element applications.

464. Computer-Aided Design II

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.

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.

499. Independent Study

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

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.

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*

Spring of odd-numbered years. 4(4-0) C E 828 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; unsteady open channel flow; oscillatory waves; similitude and models.

830. *Intermediate Fluid Mechanics*

(840.) 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 432; MTH 322 or 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) MMM 810; MTH 322 or 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 hotwire 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.

854. *Optimization Theory and Applications*

(862.) Winter. 4(4-0) MTH 424 or approval of department.

Formulation of optimization problems; projection methods and least squares theory; elementary fundamentals of calculus of variations; techniques applied to problems in dynamics, optimization of airfoil shapes, and fuel consumption.

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.

920. *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.

921. *Theory of Vibrations III*

Spring of odd-numbered years, Summer. 4(4-0) MMM 920 or approval of department. Interdepartmental with and administered by the Department of Metallurgy, Mechanics and Materials Science.

Nonlinear oscillations. Resonance; subharmonics; self-sustained motions; stability. Methods of Poincare, van der Pol, etc. Random vibrations. Parametric excitations; stochastic processes; power spectra. Applications.

925. *Mechanical Engineering Problems*

Fall, Winter, Spring, Summer. Variable credit. May reenroll for a maximum of 9 credits. Approval of department.

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

970. *Wave Motion in Continous Media II*

Spring of even-numbered years. 4(4-0) M E 870 or approval of instructor.

Continuation of M E 870.

999. *Doctoral Dissertation Research*

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