921 Functional Analysis II
Fall of even years. 3(3-0) P:NM: (MTH 829 and MTH 920)
Topological vector spaces, convexity, Krein-Milman theorem, Banach algebras, operators on Banach spaces, spectral theorem, C*-algebras.

922 Harmonic Analysis
Fall of odd years. 3(3-0) P:NM: (MTH 829 and MTH 920)
Fourier series, mean and pointwise convergence, conjugate functions, Fourier transform, Plancherel theorem, Paley-Wiener theorem, interpolation of operators, Hausdorff-Young thoerem.

928 Real Analysis II
Fall. 3(3-0) P:NM: (MTH 828)
Positive Borel measure, complex measures. Riesz representation theorem, Radon-Nikodym theorem, Lebesgue decomposition theorem. Differentiable transformations and change of variables, differentiation of measures, maximal functions.

929 Complex Analysis II
Spring. 3(3-0) P:NM: (MTH 828 and MTH 829)
Phragmen-Lindelof method. Hadamard's theorem, Runge's thoerem, Weierstrass factorization theorem, Mittag-Leffler theorem, and Picard's theorem. Poisson integrals, Harnack's inequality, Dirichlet problem. Hp-spaces and Blaschke products.

930 Riemannian Geometry I
Fall. 3(3-0) P:NM: (MTH 869)
Riemannian metrics, connections, curvature, geodesics. First and second variation, Jacobi fields, conjugate points. Rauch comparison theorems, Hodge theorem, Bochner technique, spinors. Further topics on curvature or submanifold theory.

931 Riemannian Geometry II
Spring. 3(3-0) P:NM: (MTH 930)
Continuation of MTH 930.

935 Complex Manifolds I
Fall of odd years. 3(3-0) P:NM: (MTH 829 and MTH 869)
Riemann surfaces, Serre duality, Riemann-Roch theorem. Weierstrass points, Abel's theorem, Plucker formulas. Hermitian metrics, connections, curvature, Hodge theorem. Kaehler metrics, Kodaira vanishing theorem, Chern classes.

936 Complex Manifolds II
Spring of even years. 3(3-0) P:NM: (MTH 935)
Continuation of MTH 935.

940 Applied Analysis I
Fall. 3(3-0) P:NM: (MTH 828)
Sobolev spaces, trace theorem, imbedding theorems, sectorial forms. Linear elliptic boundary and eigenvalue problems.

941 Applied Analysis II
Spring. 3(3-0) P:NM: (MTH 940)
Fixed point theorems. Variational methods. Applications to nonlinear integral and elliptic differential equations. Semigroup theory.

942 Foundations of Applied Mathematics I
Fall. 3(3-0) P:NM: (MTH 848 and MTH 849)
Modeling in classical applied mathematics. Newtonian and continuum mechanics. Special mathematical techniques.

943 Foundations of Applied Mathematics II
Spring. 3(3-0) P:NM: (MTH 942)
Continuation of MTH 942.

950 Numerical Methods for Partial Differential Equations I
Spring of odd years. 3(3-0) P:NM: (MTH 852)
Finite difference methods for ordinary and partial differential equations.

951 Numerical Methods for Partial Differential Equations II
Spring of even years. 3(3-0)
Finite element methods for ordinary and partial differential equations.

960 Algebraic Topology I
Fall. 3(3-0) P:NM: (MTH 869)
Cohomology, products, duality, basic homotopy theory, bundles, obstruction theory, spectral sequences, characteristic classes, and other related topics.

961 Algebraic Topology II
Spring. 3(3-0) P:NM: (MTH 960)
Continuation of MTH 960.

990 Reading in Mathematics
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 9 credits in all enrollments for this course. R: Approval of department.
Individualized study for doctoral level students.

991 Special Topics in Algebra
Fall, Spring. 3 to 6 credits. A student may earn a maximum of 18 credits in all enrollments for this course. R: Approval of department.
Advanced topics in algebra.

992 Special Topics in Analysis
Fall, Spring. 3 to 6 credits. A student may earn a maximum of 18 credits in all enrollments for this course. R: Approval of department.
Advanced topics in analysis.

993 Special Topics in Geometry
Fall, Spring. 3 to 6 credits. A student may earn a maximum of 18 credits in all enrollments for this course. R: Approval of department.
Advanced topics in geometry.

994 Special Topics in Applied Mathematics
Fall, Spring. 3 to 6 credits. A student may earn a maximum of 18 credits in all enrollments for this course. R: Approval of department.
Advanced topics in applied mathematics.

995 Special Topics in Numerical Analysis and Operations Research
Fall, Spring. 3 to 6 credits. A student may earn a maximum of 18 credits in all enrollments for this course. R: Approval of department.
Advanced topics in numerical analysis or operations research.

996 Special Topics in Topology
Fall, Spring. 3 to 6 credits. A student may earn a maximum of 18 credits in all enrollments for this course. R: Approval of department.
Advanced topics in topology.

998 Special Topics in Combinatorics and Graph Theory
Fall, Spring. 3 to 6 credits. A student may earn a maximum of 18 credits in all enrollments for this course. R: Approval of department.
Advanced topics in combinatorics and graph theory.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 99 credits in all enrollments for this course. R: Approval of department.
Doctoral dissertation research.

MECHANICAL ENGINEERING ME

Department of Mechanical Engineering
College of Engineering

201 Thermodynamics
Fall, Spring. 3(3-0) P:M: (CEM 141 or CEM 151 or CEM 181H or LBS 165) and (MTH 234 or concurrently or MTH 254H or concurrently or LBS 220 or concurrently) Not open to students with credit in CHE 321 or MSM 351 or BE 351.
Basic concepts of thermodynamics. Property evaluation of ideal gases and compressible substances. Theory and application of the first and second laws of thermodynamics. Entropy and Carnot efficiency.

332 Fluid Mechanics
Fall, Spring. 4(3-3) P:M: (MSM 306) and (CHE 311 or ME 201 or MSM 351) and (ME 391 or concurrently) and completion of Tier I writing requirement. R: Open only to juniors or seniors in the Department of Mechanical Engineering or in the Engineering Mechanics major.
Statics, control volume equations, similitude, exact fluid solutions. Turbulence, pipe flow, boundary layer flow, compressible flow, and Navier-Stokes equations.

371 Mechanical Design I
Fall, Spring. 3(3-0) P:M: (MSM 306 or concurrently) R: Open only to juniors or seniors in the Department of Mechanical Engineering or in the Engineering Mechanics major.
Analysis of displacement, velocity and acceleration in mechanical linkages. Kinematics and dynamics of machines.

391 Mechanical Engineering Analysis
Fall, Spring. 3(3-0) P:M: (MTH 235 or MTH 255H or LBS 220) R: Open only to juniors or seniors in the Department of Mechanical Engineering or in the Biosystems Engineering or Engineering Mechanics major.
Analytical and numerical methods for the modeling and analysis of mechanical engineering systems. Applications to vibrating elements, heat transfer, linear springs, and coupled spring-mass systems.

410 Heat Transfer
Fall, Spring. 3(3-0) P:M: (ME 332 or CE 321 or CHE 311) and (ME 391) and completion of Tier I writing requirement. R: Open only to juniors or seniors in the Department of Mechanical Engineering or in the Biosystems Engineering or Engineering Mechanics major.
Steady state and transient heat conduction. Natural and forced convection based on boundary layer theory. Application of Nusselt number correlations. Radiant heat transfer principles and applications including radiation networks.

412 Heat Transfer Laboratory
Fall, Spring. 2(1-2) P:M: (ME 410) and completion of Tier I writing requirement. R: Open only to juniors or seniors in the Department of Mechanical Engineering.
Practices and measurement techniques for heat transfer and thermal systems. Experimental problem solving applied to heat transfer.

414 Vehicle Thermal System Design
Spring. 3(2-2) Spring: Engineering Building. P:M: (ME 410) R: Open only to seniors in the College of Engineering.
Analysis and design of general heat exchange systems applied to automotive vehicle systems including heaters, air conditioning, electronic, and cabin systems. Students will work in teams to design, build, and test heat exchanger systems. A global engineering experience via the internet may be included.

416 Computer Assisted Design of Thermal Systems
Fall. 3(4-0) P:M: (ME 410 or concurrently) R: Open only to juniors or seniors in the Department of Mechanical Engineering or in the Biosystems Engineering major.
Classifying, cataloging and processing design information. Modeling of thermal equipment. Simulation and optimization of thermal systems. Computer based design projects.

422 Introduction to Combustion
Fall. 3(3-0) P:M: (ME 332 or concurrently) R: Open only to juniors or seniors in the Department of Mechanical Engineering.
Thermodynamics, chemistry, fluid mechanics, and heat transfer principles applied to combustion.

432 Intermediate Fluid Mechanics
Spring. 3(3-0) P:M: (ME 332) R: Open only to juniors or seniors in the Department of Mechanical Engineering or in the Engineering Mechanics major.
Deformable control volumes, Navier-Stokes equations, vorticity and circulation. Exact solutions. Turbulence, boundary layer flows, compressible flows.

440 Aerospace Engineering Fundamentals
Fall. 3(3-0) P:M: (ME 332 or concurrently) R: Open only to juniors or seniors in the Department of Mechanical Engineering or in the Engineering Mechanics major.
Aerodynamics, propulsion and flight mechanics. Vehicle and propulsion engine performance and design characteristics.

442 Turbomachinery
Spring. 3(3-0) P:M: (ME 332) R: Open only to juniors or seniors in the Department of Mechanical Engineering.
Applying energy, momentum, and continuity equations of thermo-fluids to turbomachinery. Blade geometry and aerodynamics. Performance and design parameters. Turbomachine design.

444 Automotive Engines
Spring. 3(3-0) P:M: (ME 410 or concurrently) R: Open only to juniors or seniors in the College of Engineering.
Design and development of internal and external combustion engines for vehicular propulsion.

445 Automotive Powertrain Design
Spring. 3(3-0) P:M: (ME 444) P:NM: (ME 444) R: Open only to juniors or seniors in the Department of Mechanical Engineering.
Design of powertrain systems including piston ring assembly, combustion and induction systems, and transmissions. Performance emission tradeoffs with emphasis on emission control. Detailed design study required.

451 Control Systems
Fall, Spring. 4(3-3) P:M: (MSM 306 and ECE 345) and completion of Tier I writing requirement. R: Open only to juniors or seniors in the Department of Mechanical Engineering or in the Engineering Mechanics major.
Mathematical modeling of dynamic systems. Standard feedback control formulation. Transient and sinusoidal steady state analysis. Time and frequency domain controller synthesis.

456 Mechatronic System Design
Fall. 3(2-3) P:M: (ECE 345 and ME 451 or concurrently) R: Open only to juniors or seniors in the Department of Mechanical Engineering.
Application of imbedded microcontrollers to the design of mechatronic systems. Design of software and hardware for systems with mechanical, electrical and fluid components plus imbedded control systems. Laboratory exercises and design projects. Application to automotive, consumer and commercial systems.

457 Mechatronic System Modeling and Simulation
Spring. 3(3-0) P:M: (ECE 345 and MSM 306) R: Open only to juniors or seniors in the Department of Mechanical Engineering and to students in the Master of Science degree in Industrial Mathematics.
Modeling and simulation of mechatronic systems, including mechanical, electrical, fluid, power, and other effects. Transducer modeling, including pumps, motors, and valves. Application to automotive systems.

461 Mechanical Vibrations
Fall, Spring. 4(3-3) P:M: (ME 451) and completion of Tier I writing requirement. R: Open only to juniors or seniors in the Department of Mechanical Engineering or in the Engineering Mechanics major.
Modeling and analysis of oscillatory phenomena found in linear discrete and continuous mechanical systems.

465 Computer Aided Optimal Design
Fall. 3(3-0) P:M: (ME 471 or concurrently) R: Open only to juniors or seniors in the Department of Mechanical Engineering.
Modeling for mechanical design optimization. Algorithms for constrained and unconstrained optimization. Optimality criteria. Optimization using finite element models. Design projects.

471 Mechanical Design II
Fall, Spring. 3(3-0) P:M: (ME 371) and (ME 391) and (MSM 211) R: Open only to juniors or seniors in the Department of Mechanical Engineering or in the Engineering Mechanics major.
Engineering design of machine elements and mechanical systems. Computer based analysis in support of design. Design for static and fatigue strength, deflection and reliability.

475 Computer Aided Design of Automotive Structures
Fall. 3(2-2) P:M: (ME 471 or concurrently) R: Open only to seniors in the Department of Mechanical Engineering.
Computational methods for analysis, design, and optimization of automotive structural components. Basic concepts in geometric modeling, finite element analysis, and structural optimization.

481 Mechanical Engineering Design Projects
Fall, Spring. 3(1-6) P:M: (ME 410) and (ME 471) and completion of Tier I writing requirement. R: Open only to juniors or seniors in the Department of Mechanical Engineering.
Application of design concepts in mechanical engineering. Problem definition, design specifications. Modeling and analysis methods. Design optimization, economics, reliability. Manufacturing considerations in design. Capstone design projects.

490 Independent Study in Mechanical Engineering
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to juniors or seniors in the Department of Mechanical Engineering. Approval of department.
Independent study in mechanical engineering.

491 Selected Topics in Mechanical Engineering
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 8 credits in all enrollments for this course. R: Open only to juniors or seniors in the Department of Mechanical Engineering. Approval of department.
Topics selected to supplement and enrich existing courses.

802 Advanced Classical Thermodynamics
Fall. 3(3-0) P:NM: (ME 391 and ME 411)
Postulational treatment of the laws of thermodynamics. Equilibrium and maximum entropy postulates. Principles for general systems.

804 Micro-Scale Fluid Mechanics and Heat Transfer
Spring of odd years. 3(3-0) P:NM: (ME361 and ME332 and ME410)
Basic concepts of micro-scale processes. Molecular derivation of the conservation equations of fluid dynamics, Boltzmann equation and Monte-Carlo methods of modern micro-applied science. Theory of micro-scale heat transfer. Applications to fluid mechanics, heat transfer, combustion.

809 Finite Element Method
Fall, Spring. 3(3-0) Interdepartmental with Materials Science and Mechanics; Civil Engineering; Biosystems Engineering. Administered by Department of Materials Science and Mechanics. SA: AE 809
Theory and application of the finite element method to the solution of continuum type problems in heat transfer, fluid mechanics, and stress analysis.

812 Conductive Heat Transfer
Fall. 3(3-0) P:NM: (ME 391 and ME 411)
Theory of steady and unsteady heat conduction. Derivation of describing equations and boundary conditions. Numerical methods. Nonlinear problems.

814 Convective Heat Transfer
Spring. 3(3-0)
Analysis of convective transfer of heat, mass and momentum in boundary layers and ducts. Thermal instability. Free convection.

822 Combustion
Spring. 3(3-1) P:NM: (ME 490 and ME 802)
Thermodynamics and chemical kinetics. Multicomponent systems. Premixed and diffusion flames, flame radiation.

830 Fluid Mechanics I
Fall. 3(3-0)
Integral and differential conservation laws, Navier-Stokes' equations, and exact solutions. Laminar boundary layer theory, similarity solutions, and approximate methods. Thermal effects and instability phenomena.

832 Fluid Mechanics II
Spring of even years. 3(3-0) P:NM: (ME 830 and MTH 425)
Inviscid flow, vortex motion, flow past bodies. Complex variables and conformal mapping. One-dimensional steady and unsteady compressible flow, shock waves and Prandtl-Meyer expansion. Small perturbations theory and method of characteristics.

834 Fundamentals of Turbulence
Fall of odd years. 3(3-0)
Statistical descriptions of turbulent flows: isotropic, free shear and wall bounded. Correlation and spectral descriptions. Conditional probabilities and coherent motions. Experimental methods. Scaling relationships.

836 Experimental Methods in Fluid Mechanics
Fall of even years. 3(1-4)
Modern techniques of fluid mechanics measurement and data analysis. Pressure, temperature and velocity measurement techniques. Optical diagnostics.

840 Computational Fluid Dynamics and Heat Transfer
Spring. 3(3-0) P:NM: (ME 410) and (ME 830 or ME 814) and programming experience.
Theory and application of finite difference and finite volume methods to selected fluid mechanics and heat transfer models including the full potential flow model, the systems of Euler and Navier-Stokes equations, and turbulence. Grid generation techniques.

842 Advanced Turbomachinery
Spring of even years. 3(3-0) P:NM: (ME 442) R: Open only to seniors and graduate students in Mechanical Engineering and Chemical Engineering.
Application of energy, momentum, continuity and heat transfer equations to energy transfer and transformation in turbomachinery.

852 Intermediate Control Systems
Spring. 3(3-0) P:NM: (ME 451)
Design of controllers for dynamic systems in mechanical engineering. Modeling, analysis and simulation.

855 Digital Data Acquisition and Control
Spring of odd years. 3(2-3) P:NM: (ME 451)
Real-time digital measurement and control programming for mechanical engineering systems. Analog-to digital and digital-to-analog converters, timer/counters, and instrument interfaces. Open-loop and closed-loop control. Laboratory projects.

857 Modeling and Simulation of Dynamic Systems
Fall. 3(3-0) P:NM: (ME 451)
Energy-based methods for modeling dynamic engineering components and systems. Systematic formulation of nonlinear state-space equations. Qualitative aspects of response: equilibrium points, linearization. Simulation techniques and design projects.

860 Theory of Vibrations
Fall. 3(3-0) Interdepartmental with Materials Science and Mechanics.
Discrete systems and continua. Analytical mechanics. Variational principles. Modal analysis. Function spaces. Eigenfunction expansions. Integral transforms. Stability. Approximations. Perturbations.

863 Nonlinear Vibrations
Spring of even years. 3(3-0) P:NM: (ME 461)
Perturbation methods. Weakly nonlinear partial and ordinary differential equations. Modal interactions, internal tuning, saturation, sub/super/combination resonances, jump phenomenon. Nonlinear normal modes.

874 Analysis of Metal Forming and Manufacturing Processes
Fall of odd years. 3(3-0) P:NM: (ME 471 and MSM 809 and MSM 817 and MSM 810)
Review of fundamental knowledge in mechanics, materials and numerical analysis. Modeling, simulation and analysis of metal forming and manufacturing processes.

875 Optimal Design of Mechanical Systems
Spring of odd years. 3(3-0) P:NM: (ME 461)
Optimal design for static and dynamic response of mechanical and structural systems. Necessary and sufficient conditions for optimality. Discrete and continuous parameter problems. Sensitivity of response to design variations. Algorithms.

891 Selected Topics in Mechanical Engineering
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Approval of department.
Special topics in mechanical engineering of current importance.

892 Parameter Estimation
Fall of odd years. 3(3-0) P:NM: (STT 421 or STT 441)
Nonlinear estimation of parameters in ordinary and partial differential equations. Related concepts in probability and statistics. Least squares and other estimators. Sequential methods. Optimum experiment design.

898 Master's Project Research
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 7 credits in all enrollments for this course. R: Open only to master's students in the Mechanical Engineering major. Approval of department.
Master's degree Plan B individual student project: original research, research replication, or survey and reporting on a topic such as system design and development, or system conversion of installation.

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 8 credits. A student may earn a maximum of 24 credits in all enrollments for this course.
Master's thesis research.

913 Advanced Heat Conduction
Fall of even years. 3(3-0) P:NM: (ME 812 or MTH 849)
Inverse and ill-posed problems in heat transfer: function estimation, regularization, and adjoint methods in conduction.

940 Selected Topics in Thermal Science
Spring. 1 to 3 credits. A student may earn a maximum of 12 credits in all enrollments for this course. P:NM: (ME 812 and ME 814 and ME 816) R: Open only to Mechanical Engineering majors.
Conduction, convection, radiation, phase change and interactive combined modes of heat transfer. Mass transfer. Irreversible thermodynamics.

960 Selected Topics in Vibrations
Fall. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. P:NM: (ME 860)
Current topics of interest to the student and faculty.

961 Nonlinear Dynamics and Chaos
Fall of even years. 3(3-0) P:NM: (ME 857 or ME 860 or EDE 826 or MTH 441)
Qualitative theory of dynamical systems applied to physical system models. Bifurcation theory for continuous and discrete-time systems, chaos, the Smale horseshoe, Melnikov's method, and nonlinear data analysis.

990 Independent Study in Mechanical Engineering
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course.
Individualized study of a current problem in mechanical engineering.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 72 credits in all enrollments for this course.
Doctoral dissertation research.

MEDICAL TECHNOLOGY MT

Medical Technology Program
College of Natural Science

212 Fundamentals of Laboratory Analysis
Fall, Summer. 3(3-0) P:M: (MTH 103 or MTH 116 or LBS 117) RB: (BS 111L)
Chemical, biological and instrumental concepts in laboratory analyses: quality assurance, laboratory mathematics, safety, health care systems and regulatory issues.