921 Functional Analysis II
Fall of even years. 3(3-0) P:N:M: (MTH 829 and MTH 920)

922 Harmonic Analysis
Fall of odd years. 3(3-0) P:N:M: (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 theorem.

928 Real Analysis II
Fall. 3(3-0) P:N:M: (MTH 828)

929 Complex Analysis II
Spring. 3(3-0) P:N:M: (MTH 828 and MTH 899)

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

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

935 Complex Manifolds I
Fall of odd years. 3(3-0) P:N:M: (MTH 829 and MTH 869)

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

940 Applied Analysis I
Fall. 3(3-0) P:N:M: (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:N:M: (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:N:M: (MTH 848 and MTH 849)

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

950 Numerical Methods for Partial Differential Equations I
Spring of odd years. 3(3-0) P:N:M: (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:N:M: (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:N:M: (MTH 960)
Continuation of MTH 960.

993 Special Topics in Geometry
Fall, Spring. 3 to 6 credits. A student may earn a maximum of 9 credits in all enrollments for this course. R: Approval of department.

995 Special Topics in Numerical 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.

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.

ME–Mechanical Engineering

MECHANICAL ENGINEERING

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.
Mechanical Engineering–ME

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.


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) P:ME: 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.

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 thermofluids to turbomachinery. Blade geometry and aerodynamics. Performance and design parameters. Turbomachinery 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. 3(3-3) P:M: (MEM 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.


456 Mechatronic System Design
Fall. 3(3-0) P:M: (ECE 345) and (ME 451 or concurrently) R: Open only to juniors or seniors in the Department of Mechanical Engineering.

Application of embedded microcontrollers to the design of mechatronic systems. Design of software and hardware for systems with mechanical, electrical and fluid components plus embedded 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.


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.

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.


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.

Topics selected to supplement and enrich existing courses.

802 Advanced Classical Thermodynamics
Fall. 3(3-0) P:NM: (ME 391 and ME 411)


804 Micro-Scale Fluid Mechanics and Heat Transfer
Spring. 3(3-0) P:NM: (ME361 and ME332 and ME410)

809 Finite Element Method  
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)  

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 instabilities phenomena.

832 Fluid Mechanics II  
Spring of even years. 3(3-0) P-NM: (ME 830 and MTH 425)  

834 Fundamentals of Turbulence  
Fall of odd years. 3(3-0)  

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, and kinetic heat transfer equations to energy transfer and transformation in turbomachinery.

852 Intermediate Control Systems  
Spring. 3(3-0) P-NM: (ME 451)  

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)  

860 Theory of Vibrations  
Fall. 3(3-0) Interdepartmental with Materials Science and Mechanics.  

863 Nonlinear Vibrations  
Spring of even years. 3(3-0) P-NM: (ME 461)  

874 Analysis of Metal Forming and Manufacturing Processes  
Fall of odd years. 3(3-0) P-NM: (ME 471 and MMS 809 and MMS 817 and MMS 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)  

891 Selected Topics 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: 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)  

896 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.  

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.

**MT–Medical Technology**

**Medical Technology Program**

**College of Natural Science**

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