960. Algebraic Topology I
Fall. 3(3-0)
P: 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: MTH 960.
Continuation of MTH 960.

990. Reading in Mathematics
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 8 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.

MECHANICAL ENGINEERING ME

Department of Mechanical Engineering
College of Engineering

201. Thermodynamics
Fall, Spring. 3(3-0)
P: CEM 141, MTH 234 or concurrently. R: Not open to students with credit in CHE 311 or MSM 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.

311. Introduction to Biomedical Engineering
Fall. 3(3-0) Interdepartmental with Biomedical Engineering, Materials Science and Mechanics, and Electrical Engineering. Administered by Biomedical Engineering.
P: BS 111, MTH 235, PHY 184.
Physical and mechanical properties of soft and hard tissues. Biomaterials. Biocompatibility. Biochemical processes, biological transport, and thermodynamics. Bioelectronics and instrumentation.

332. Fluid Mechanics
Fall, Spring. 4(3-3)
P: MSM 306; CHE 311 or ME 201 or MSM 351; ME 391 or concurrently. R: Open only to juniors and seniors in Mechanical Engineering and Mechanics. Completion of Tier I writing requirement.
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: MSM 306 or concurrently. R: Open only to Mechanical Engineering and Mechanics majors.
Analysis of displacement, velocity and acceleration in mechanical linkages. Kinematics and dynamics of machines.

391. Mechanical Engineering Analysis
Fall, Spring. 3(3-0)
P: MTH 235. R: Open only to majors in Mechanical Engineering, Agricultural Engineering, and Mechanics.
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: ME 332 or CE 321 or CHE 311; ME 391. R: Open only to Mechanical Engineering, Food Engineering, and Mechanics majors.
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.

411. Applied Thermal Science
Fall, Spring. 3(3-0)
P: ME 410. R: Open only to Mechanical Engineering majors.
Thermodynamic principles as applied to gas and vapor power and refrigeration cycles for reciprocating and turbo machinery. Combustion. Analysis and design of heat exchangers. Numerical analysis of heat conduction.

412. Heat Transfer Laboratory
Fall, Spring. 1(1-2)
P: ME 411 or concurrently. R: Open only to Mechanical Engineering majors. Completion of Tier I writing requirement.
Practices and measurement techniques for heat transfer and thermal systems. Experimental problem solving applied to heat transfer.

415. Solar Energy Conversion
Spring. 3(3-0)
P: ME 410. R: Open only to Mechanical Engineering majors.
Solar radiation: terrestrial diffuse and direct-beam insolation. Flat-plate and focusing collectors. Energy storage systems. Solar-assisted heat pumps. Photovoltaic, biomass and wind energy conversions.

416. Computer Assisted Design of Thermal Systems
Fall. 3(4-0)
P: ME 411. R: Open only to Mechanical Engineering majors.
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: ME 332. R: Open only to Mechanical Engineering majors.
Thermodynamics, chemistry, fluid mechanics, and heat transfer principles applied to combustion.

432. Intermediate Fluid Mechanics
Spring. 3(3-0)
P: ME 332. R: Open only to Mechanical Engineering majors.
Deformable control volumes, Navier-Stokes equations, vorticity and circulation. Exact solutions. Turbulence, boundary layer flows, compressible flows.

433. Intermediate Fluid Mechanics Laboratory
Spring. 1(0-3)
P: ME 432 or concurrently. R: Open only to Mechanical Engineering majors.
Visualization and measurement of flow, jets and wakes. Flow separation and boundary layers.

435. Biological Transport Mechanisms
Fall of odd-numbered years. 3(3-0) Interdepartmental with Biomedical Engineering and Chemical Engineering. Administered by Biomedical Engineering.
P: BME 311, MTH 235.
Mechanisms of transport of momentum, heat and mass. Mathematical description of transport processes in biological systems. Solution of biomedical problems.

440. Aerospace Engineering I
Fall. 3(3-0)
P: ME 332. R: Open only to Mechanical Engineering and Mechanics majors.
Aerodynamics, propulsion and flight mechanics. Vehicle and propulsion engine performance and design characteristics.

441. Aerospace Engineering II
Spring. 3(3-0)
P: ME 440. R: Open only to Mechanical Engineering and Mechanics majors.
Computer analysis experiments associated with aerospace vehicle design. Application of aerospace engineering principles in design such as propulsion, aerodynamics, stability and control.

442. Turbomachinery
Spring. 3(2-3)
P: ME 201, ME 332. R: Open only to majors in 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: ME 391; ME 410 or concurrently. R: Open only to majors in College of Engineering.
Design and development of internal and external combustion engines for vehicular propulsion.

451. Control Systems
Fall, Spring. 4(3-3)
P: ME 391, MSM 306, EE 345. R: Open only to Mechanical Engineering and Mechanics majors. Completion of Tier I writing requirement.
Mathematical modeling of dynamic systems. Standard feedback control formulation. Transient and sinusoidal steady state analysis. Time and frequency domain controller synthesis.

461. Mechanical Vibrations
Fall, Spring. 4(3-3)
P: ME 451. R: Open only to Mechanical Engineering and Mechanics majors. Completion of Tier I writing requirement.
Modeling and analysis of oscillatory phenomena found in linear discrete and continuous mechanical systems.

463. Computer Aided Design of Dynamic Systems
Spring. 3(3-0)
P: ME 451. R: Open only to Mechanical Engineering, and Mechanics majors.
Modeling and design of mechanical and mixed-energy dynamic systems. State-space equation representation. Simulation methods.

465. Computer Aided Optimal Design
Fall. 3(3-0)
P: ME 471 or concurrently. R: Open only to Mechanical Engineering majors.
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: ME 371, ME 391. R: Open only to Mechanical Engineering and Mechanics majors.
Engineering design of machine elements and mechanical systems. Computer based analysis in support of design. Design for static and fatigue strength, deflection and reliability.

481. Mechanical Engineering Design Projects
Fall, Spring. 3(1-6)
P: ME 411 or concurrently; ME 471. R: Open only to Mechanical Engineering majors. Completion of Tier I writing requirement.
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 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course.
R: Open only to Mechanical Engineering majors. 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 Mechanical Engineering majors. Approval of department.
Topics selected to supplement and enrich existing courses.

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

809. Finite Element Method
Fall. 3(3-0) Interdepartmental with Materials Science and Mechanics, Agricultural Engineering, and Civil Engineering. Administered by Materials Science and Mechanics.
R: Approval of department.
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: ME 391, 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.

816. Radiative Heat Transfer
Fall. 3(3-0)
P: ME 410.
Electromagnetic theory of radiation. Spectral properties of diffuse and nondiffuse surfaces. Radiation exchange. Radiative transfer in media. Gaseous radiation exchange. Combined modes.

822. Combustion
Spring. 3(3-1)
P: ME 490, 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. 3(3-0)
P: ME 830, 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
Spring. 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. 3(1-4)
Modern techniques of fluid mechanics measurement and data analysis. Pressure, temperature and velocity measurement techniques. Optical diagnostics.

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

855. Digital Data Acquisition and Control
Spring of odd-numbered years. 3(2-3)
P: 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: 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.
P: ME 452.
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-numbered years. 3(3-0)
P: 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.

871. Elastodynamics of Machinery and Robotic Systems
Fall of even-numbered years. 3(3-0)
Rigid-body kinematic analysis. Linkage synthesis. Variational formulations, nonlinear phenomena, composites and smart materials.

873. Design-for-Manufacture Strategies for Composite Materials
Spring of odd-numbered years. 3(3-0)
Modeling of fiberous composite materials. Processing techniques for thermoplastics and thermosets. Design-for-Manufacture (DFM) strategies.

875. Optimal Design of Mechanical Systems
Spring of even-numbered years. 3(3-0)
P: 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.

892. Parameter Estimation
Spring. 3(3-0)
P: 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.

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.

902. Random Vibration of Structural and Mechanical Systems
Spring of odd-numbered years. 3(3-0) Interdepartmental with Civil Engineering, and Materials Science and Mechanics. Administered by Civil Engineering.
P: CE 802 or ME 860; CE 810.
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.

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

930. Selected Topics in Fluid Mechanics
Fall. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course.
P: ME 830.
Current topics in fluid mechanics will be presented.

934. Application of Turbulence Fundamentals
Spring. 3(3-0)
P: ME 834.
Fundamental physics of turbulence from dimensional analysis approach. Classical and coherent structure analysis.

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: ME 812, ME 814, 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.

952. Advanced Control Systems
Fall. 3(3-0)
P: ME 852.
Current topics in control theory with potential for improving mechanical systems design.

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: ME 860.
Current topics of interest to the student and faculty.

963. Wave Phenomena
Spring of even-numbered years. 3(3-0)
R: Approval of department.
Linear and non-linear waves in bounded and unbounded media. Reflection, refraction, diffraction. Dispersion. Shock and acceleration waves. Waveguides. Acoustical and optical analogies. Fluid and solid continua.

971. Intelligent Materials and Smart Structures: Applications
Fall of odd-numbered years. 3(3-0)
P: ME 873.
Design-for-manufacture issues in smart materials: biomimetics, nanotechnology, electro-rheological fluids, shape memory alloys, piezoelectric materials, fiberoptics, neural networks.

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.

MEDICAL TECHNOLOGY MT

Medical Technology Program
College of Natural Science

212. Fundamentals of Laboratory Analysis
Fall. 3(3-0)
P: MTH 103 or MTH 116; CEM 141 and CEM 161.
Chemical, biological and instrumental laboratory analyses: method evaluation, quality assurance, and predictive value theories.

213. Application of Clinical Laboratory Principles
Fall. 1(0-3)
C: MT 212. R: Open only to students in Clinical Laboratory Sciences, and Medical Technology.
Microscopy, pipetting. Specimen collection, handling and processing. Laboratory safety, quality control, and method evaluation.

406. Medical Mycology
Spring. 3(2-3) Interdepartmental with Botany and Plant Pathology, and Microbiology. Administered by Botany and Plant Pathology.
P: BOT 402, MIC 302.
Characteristics and laboratory identification of fungal diseases in humans and other animals. Laboratory techniques. Morphology of causative fungi.

414. Clinical Chemistry and Body Fluid Analysis
Spring. 4(4-0)
P: BCH 401, MT 212, PSL 250; STT 200 or STT 201.
Analytical methods in clinical chemistry and urinalysis. Correlation of laboratory test results with physiology and diseases of renal, hepatic and cardiac systems.

415. Clinical Chemistry and Body Fluid Analysis Laboratory
Spring. 1(0-3)
P: MT 213. C: MT 414. R: Open only to Clinical Laboratory Sciences majors.
Quantitative analysis of blood and body fluids. Spectophotometry, electrophoresis, chromatography, enzymatic assays, and immunoassays.

416. Clinical Chemistry
Fall. 4(4-0)
P: MT 212, BCH 401.
Analytical methods in clinical chemistry. Correlation of laboratory test results with physiology and diseases of the endocrine system, pregnancy, and cancer. Therapeutic drug monitoring and automation.

422. Hematology and Hemostasis
Fall. 4(4-0)
P: MT 212; BCH 401 or concurrently.
Structure and function of normal blood cells with changes seen in benign and malignant diseases, and in acquired and hereditary diseases.

423. Hematology and Hemostasis Laboratory
Fall. 1(0-3)
P: MT 213. C: MT 422. R: Open only to Clinical Laboratory Sciences majors.
Diagnostic assessment of blood cells and hemostatic function.

432. Clinical Immunology and Immunohematology
Spring. 5(5-0)
P: MT 212.
Cellular and humoral immunity, diseases of immunity. Clinical serology and immunology, blood group serology, and transfusion practices.

433. Clinical Immunology and Immunohematology Laboratory
Spring. 1(0-3)
P: MT 213. C: MT 432. R: Open only to majors in Clinical Laboratory Sciences.
Immunologic methods for disease detection. Methods of blood typing and pre-transfusion testing.

442. Education and Management in the Clinical Laboratory
Fall. 3(3-0)
R: Open only to majors in Clinical Laboratory Sciences.
Concepts of management in clinical laboratory practice. Program accreditation and certification. Government regulation. Personnel recruitment and selection. Performance evaluation. Financial management.

454. Problem Solving Across Clinical Laboratory Disciplines (W)
Spring. 4(4-0)
P: MT 212, MT 213, MT 414, MT 415, MT 416, MT 422, MT 423, MT 432, MT 433, MIC 463, MIC 464. R: Open only to seniors in Clinical Laboratory Sciences. Completion of Tier I writing requirement.
Problem-oriented approach integrates topics from previous courses in clinical laboratory sciences, social sciences, and humanities. Emphasis on published primary research literature and its critical appraisal.

455. Integrating Clinical Laboratory Science Discipline (W)
Spring. 2(2-0)
P: MT 414, MT 416, MT 422, MT 432, MIC 463. R: Open only to seniors in Medical Technology. Completion of Tier I writing requirement.
Problem oriented approach integrating topics from Medical Technology courses with emphasis on writing experience in the major and on critical thinking skills.

471. Advanced Clinical Chemistry Laboratory
Fall, Spring, Summer. 3 credits.
C: MT 472. R: Open only to seniors in Clinical Laboratory Sciences.
Application and integration of theory and technical skills of chemistry and biochemistry.

472. Advanced Clinical Chemistry
Fall, Spring, Summer. 1 credit.
C: MT 471. R: Open only to seniors in Clinical Laboratory Sciences.
Theoretical aspects of clinical chemistry. Chemical and biochemical reactions. Statistical analysis, pathophysiologic relationships, and methodologies.

473. Advanced Clinical Hematology and Body Fluids Laboratory
Fall, Spring, Summer. 4 credits.
C: MT 474. R: Open only to seniors in Clinical Laboratory Sciences.
Application of the theory of hematology, hemostasis, and body fluid analysis.