

**840. Advanced Hemostasis**  
(PTH 840.) Fall of even-numbered years. 2(2-0) M.S. candidates in Clinical Laboratory Science or approval of department. Interdepartmental with the Department of Pathology.  
Physiology, pathophysiology and laboratory evaluation of hemostatic disorders.

**611. Cardiology Clerkship**  
Fall, Winter, Spring, Summer. 2 to 12 credits. May reenroll for a maximum of 12 credits. MED 608.  
A clinical clerkship in which students evaluate in depth patients with cardiac diseases. This includes experiences with special diagnostic procedures including cardiac cuticularization, phonocardiography, echocardiography and electrocardiography.

**626. Physical Medicine and Rehabilitation Clerkship**  
Fall, Winter, Spring, Summer. 2 to 12 credits. May reenroll for a maximum of 12 credits. MED 608.  
Experience in prescription writing for physical medicine procedures, occupational therapy and rehabilitation skills.

**MEDICINE MED**

**College of Human Medicine**

**512. Infectious Diseases**  
Spring. 4(3-3) MPH 511, or approval of department. Interdepartmental with and administered by the Department of Microbiology and Public Health.  
Infectious diseases of humans, including biology of the causative microorganism, epidemiology, pathogenesis, host-parasite relationships, clinical and laboratory diagnosis, and clinical management.

**612. Nephrology Clerkship**  
Fall, Winter, Spring, Summer. 2 to 12 credits. May reenroll for a maximum of 12 credits. MED 608.  
Integrated concepts of renal physiology and pathophysiology of renal disease. Clinical experience.

**627. Rheumatology Clerkship**  
Fall, Winter, Spring, Summer. 2 to 12 credits. May reenroll for a maximum of 12 credits. MED 608.  
Combined office and hospital consultative clerkship which develops diagnostic skills in areas of rheumatic diseases.

**613. Dermatology Clerkship**  
Fall, Winter, Spring, Summer. 2 to 12 credits. May reenroll for a maximum of 12 credits. MED 608.  
Office based experience with a dermatologist to learn clinical skills in dermatology and develop observational and diagnostic skills in skin disease.

**628. Advanced Internal Medicine Clerkship**  
Fall, Winter, Spring, Summer. 2 to 18 credits. May reenroll for a maximum of 30 credits. MED 608.  
Clinical experiences which refine diagnostic and management skills in general internal medicine.

**614. Medical Chest Clerkship**  
Fall, Winter, Spring, Summer. 2 to 12 credits. May reenroll for a maximum of 12 credits. MED 608.  
A clerkship covering four aspects of chest diseases: tuberculosis, diagnosis, pulmonary function, and physiology. The student works with medical residents, utilizing outpatient and hospital facilities.

**630. Emergency Medicine Clerkship**  
Fall, Winter, Spring, Summer. 2 to 18 credits. May reenroll for a maximum of 18 credits. MED 608.  
Pathophysiology and other basic concepts will be used to explain the development of emergent conditions. Clinical diagnosis and treatment of emergencies seen in community emergency departments will be discussed.

**590. Special Problems in Medicine**  
Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 12 credits. Human Medicine students or approval of department.  
Each student will work under direction of a staff member on an experimental, theoretical or applied problem.

**615. Gastroenterology Clerkship**  
Fall, Winter, Spring, Summer. 2 to 12 credits. May reenroll for a maximum of 12 credits. MED 608.  
Referred patients with gastrointestinal problems are seen as either inpatients or outpatients. Many long term problems are followed. Patients with psychosocial problems are seen conjointly with Social Service.

**METALLURGY, MECHANICS,  
AND MATERIALS  
SCIENCE MMM**

**College of Engineering**

**607. Ambulatory Care Clerkship**  
Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 9 credits. FMP 602. Interdepartmental with the departments of Family Practice, and Pediatrics and Human Development. Administered by the Department of Family Practice.  
Outpatient experience, lasting an equivalent of 34 half-days and extending over a minimum of 26 weeks. Continuous and comprehensive patient care under supervision of appropriate physicians.

**616. Allergy Clerkship**  
Fall, Winter, Spring, Summer. 2 to 12 credits. May reenroll for a maximum of 12 credits. MED 608.  
Office and hospital based experience to learn and develop diagnostic skills in allergy with a review of basic therapeutics as they relate to allergic diseases.

**160. Engineering Communications**  
Fall, Winter, Spring. 4(3-3) MTH 108 or MTH 111 or concurrently.  
Engineering graphics, descriptive geometry, freehand sketching, graphical, numerical and computer problem solutions. Written technical reports and oral technical presentations.

**608. Internal Medicine Clerkship**  
Fall, Winter, Spring, Summer. 2 to 18 credits. May reenroll for a maximum of 42 credits. FMP 602, approval of department.  
Based in community hospitals, this clerkship will stress interviewing skills, history, physical examination, along with problem solving and therapy, and care of the whole patient leading to independence in patient management.

**617. Neurology Clerkship**  
Fall, Winter, Spring, Summer. 2 to 12 credits. May reenroll for a maximum of 12 credits. MED 608.  
A combined office and inpatient experience that will provide the student with an opportunity to learn the concepts of evaluation and management of neurological disease.

**201. Introduction to Engineering Mechanics**  
Fall. 4(4-0) PHY 237.  
Laws of mechanics governing the behavior of rigid and deformable bodies emphasizing how these laws influence engineering design. Extensive use of demonstrations.

**609. Hematology Clerkship**  
Fall, Winter, Spring, Summer. 2 to 12 credits. May reenroll for a maximum of 12 credits. MED 608.  
Development of skills in data collection, problem solving and management related to common hematologic disorders of children and adults.

**618. Infectious Disease Clerkship**  
Fall, Winter, Spring, Summer. 2 to 12 credits. May reenroll for a maximum of 12 credits. MED 608.  
The clerkship emphasizes acquisition in depth of knowledge and skills essential in solution of clinical problems in infectious and immunologic diseases. Integrated basic science input is afforded through relevant seminars.

**205. Mechanics I**  
Fall, Winter, Spring, Summer. 4(4-0) MTH 215 or concurrently.  
Vector description of forces and moments. Two and three dimensional equilibrium problems. Statics of frames and machines. Friction. Shear and moments in beams and shafts. Centroids and moments of inertia.

**610. Oncology Clerkship**  
Fall, Winter, Spring, Summer. 2 to 12 credits. May reenroll for a maximum of 12 credits. MED 608.  
Development of skills in data collection, problem solving and management of the more prevalent cancers in children and adults.

**620. Endocrinology and Metabolism Clerkship**  
Fall, Winter, Spring, Summer. 2 to 12 credits. May reenroll for a maximum of 12 credits. MED 608.  
Clinical and/or clinical-research clerkship to allow the student to work closely with patients having endocrine diseases, electrolyte abnormalities, endocrine hypertension or diabetes mellitus.

**211. Mechanics of Deformable Solids I**  
Fall, Winter, Spring, Summer. 4(4-0) MMM 205; MTH 310 concurrently, MMM 215 concurrently.  
Tension, compression, and shear. Axially loaded members. Torsion. Beam theory (stress and deflections). Stress and strain (Mohr's Circles). Columns.

## Description — Metallurgy, Mechanics, and Materials Science

of

### Courses

- 215. Solid Mechanics Laboratory**  
Fall, Winter, Spring, Summer. 1(0-2)  
MMM 211 concurrently.  
Instrumentation, physical properties of materials, comparison of experiment and theory.
- 230. Introduction to Materials Science**  
Spring. 4(4-0) *Non-Materials Science majors only.*  
A qualitative survey of metals, ceramics, and polymers, and the relationship of electronic, molecular, and crystal structure to the physical, mechanical, thermal, electrical and magnetic properties.
- 250. Introduction to Metallurgy**  
Fall, Winter, Summer. 4(3-3) CEM 141A, MTH 113.  
Structure-property relationship in metals and alloys. Mechanical properties, crystal structure, phase diagrams, iron-carbon system. Laboratory includes mechanical property tests, heat-treatment, microstructural observations.
- 270. Computer Graphics**  
Fall. 3(3-0) MMM 160, CPS 120 or approval of department.  
Use of computer controlled display systems for the solution of multidimensional problems.
- 306. Mechanics II**  
Fall, Winter, Spring, Summer. 4(4-0) MMM 205, MTH 310.  
Dynamics of particles and particle systems. Energy and momentum principles. Two and three dimensional rigid body dynamics.
- 330. Metallurgical Thermochemistry**  
Fall. 3(3-0) CEM 152 or approval of department.  
Laws of thermodynamics. Free energy of heterogeneous reactions. Gibbs' phase rule. Solutions. Quasichemical theory of solutions. Thermodynamics of surfaces and interfaces. Thermodynamics of defects.
- 350. Mechanical Properties of Materials I**  
Fall. 3(3-0) MMM 211, MMM 250.  
Concepts of stress and strain. Crystal elasticity. Anelasticity and viscoelasticity. Mechanical properties in tension and torsion. Hardness. Creep and stress rupture. Fracture. Fatigue.
- 351. Mechanical Properties of Materials II**  
Winter. 3(3-0) MMM 350.  
Crystallography of slip and twinning. Plastic deformation of single crystals. Deformation geometry in polycrystals. Elementary dislocation theory.
- 352. Mechanical Property Laboratory**  
Spring. 1(0-3) MMM 350.  
Laboratory experiments related to the topics covered in MMM 350.
- 360. Physical Metallurgy I**  
Winter. 3(3-0) MMM 250.  
Complex binary and ternary phase diagrams. Solidification structures, precipitation, clustering, order-disorder transformation. Recovery, recrystallization and grain growth.
- 361. Physical Metallurgy II**  
Spring. 3(3-0) MMM 360.  
Structure and theory of metallic phases. Diffusion in metals and alloys. Martensitic transformation, spinodal decomposition. Role of defects in physical metallurgy. Surfaces and interfaces.
- 362. Physical Metallurgy Laboratory**  
Spring. 1(0-3) MMM 360.  
Metallographic and electropolishing preparation of ferrous and non-ferrous alloy samples. Macro-etching and sulphur prints. Heat treatment of steel. Structure-property relationships.
- 400. Special Problems**  
Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 9 credits. Approval of department.  
Individualized reading and research.
- 405. Experimental Mechanics**  
Spring. 3(3-0) MMM 211, MMM 215 or approval of department.  
Techniques to measure stress, strain, vibration, motion. Includes strain gauges, accelerometers, photoelasticity, holography and moire techniques.
- 410. Mechanics of Deformable Solids II**  
Fall. 3(3-0) MMM 211.  
Stress, strain and linearly elastic material behavior. Plane strain and plane stress. Solution of two-dimensional problems. Stress concentration. Torsion. Yield criteria. Elastoplastic behavior of beams, shafts and pressurized cylinders.
- 411. Mechanics of Deformable Solids III**  
Winter. 3(3-0) MMM 410 or approval of department.  
Energy methods. Application to determinate and indeterminate problems. Introduction to the finite element method. Computational assignments.
- 412. Dynamics and Stability of Continuous Systems**  
Spring. 3(3-0) MMM 211, MMM 306.  
Stability, response and vibration of finite degree of freedom systems, beams and plates. Direct and energy approaches.
- 420. Ceramics and Refractory Materials**  
Fall. 3(3-0) MMM 250 or approval of department.  
Ceramics and glass materials as applied to high temperature and practical service. Mechanical and physical properties of industrial ceramics.
- 421. Manufacturing Producibility and Process Planning**  
Fall. 4(3-2) MMM 201 or MMM 205, MMM 230 or MMM 250.  
Manufacturing processes and process planning for the manufacturing of discrete parts and assemblies. Producibility and cost estimation as an interface with design.
- 422. Design of Manufacturing Systems**  
Winter. 3(3-0) MMM 421.  
Operation scheduling and control. Optimization of discrete unit single-stage and multiple-stage manufacturing systems. Applications of artificial intelligence.
- 423. Computer-Aided Manufacturing**  
Spring. 4(3-2) CPS 120, MMM 421 or approval of department.  
Application of computer-controlled elements in manufacturing systems including NC tools, robots, process and production control, group technology and flexible manufacturing systems and interface of these with management software.
- 425. Nondestructive Evaluation and Quality Control**  
Spring. 3(2-2) MMM 421, STT 315, E E 345.  
Nondestructive evaluation techniques, sampling, reliability, product liability. Ultrasonic, eddy-current, X-ray, dye penetrant inspection.
- 430. X-Ray Crystallography**  
Winter. 4(3-3) MMM 330.  
Symmetry, elementary crystallography, general properties of X-rays, introduction to radiation safety, interaction of X-rays with matter, application of X-ray diffraction to materials problems.
- 431. Corrosion and Oxidation**  
Fall. 3(3-0) MMM 330 or CEM 361.  
Fundamental principles of electro-metallurgical processes. Electrode potential and over-voltage. Electrode kinetic. Electroplating. Corrosion and stress corrosion. Corrosion protection. High temperature oxidation of metals and alloys.
- 442. Industrial Engineering**  
(ME 442.) Winter. 3(3-0) MMM 250 or MMM 230.  
Theory and techniques used by industry in planning for manufacturing. Process selection and design, work methods planning, production time standards, materials handling, and plant layout planning.
- 444. Nonmetallic Composite Materials**  
Winter. 3(3-0) MMM 350.  
Nature of nonmetallic composites. Anisotropy. Constitutive relations. Behavior of unidirectional composites. Failure criteria and strength. Micromechanics of a lamina. Laminar theory. Thermal and hygroscopic effects.
- 452. Diffusion in Solids**  
Spring. 3(3-0) MMM 330.  
Fick's first and second laws of diffusion. Analysis of diffusion equation, concept of uphill diffusion, chemical potential, introduction to multiphase diffusion, analysis of diffuse interface.
- 453. Phase Transformations**  
Winter of odd-numbered years, Spring of even-numbered years. 3(3-0) MMM 330, MMM 361.  
Mechanism of phase transformation by nucleation and growth, precipitation, massive, cellular transformation. Thermodynamics and kinetics of transformations. Crystallography of martensitic transformations.
- 454. Electron Theory of Solids**  
Fall. 3(3-0) PHY 289, MMM 430.  
Atomic theory of metals and alloys, free electron theories of metals, electrons in a periodic field and electromagnetic behavior.
- 456. Strengthening Mechanisms in Solids**  
Spring. 3(3-0) MMM 351.  
Theory of flow stress and work hardening. Solid solution and particle strengthening. Composite materials. Thermomechanical processing and high strength alloys. High temperature materials.
- 461. Heat Treatment and Properties of Ferrous Alloys**  
Winter. 3(3-0) MMM 360.  
Relations between microstructure, mechanical or physical properties of steels; effect of alloying elements, high-strength low-alloy steel, tool steels, stainless steels, hardenability of steels, T-T-T diagrams, carburizing, case hardening. Design of a heat-treating process for an alloy.

**462. Metal Fabrication**

Spring. 3(3-0) MMM 350.

Metallurgical principles of metal fabrication. Forging, rolling, extrusion and wire drawing. Hot and cold forging. Fabrication defects. Elasticity and plasticity theory applied to metal fabrication. Analysis of formability of competing materials.

**463. Welding Metallurgy**

Fall. 4(3-2) MMM 350 or concurrently.

Theory and applications of arc, gas, resistance and thermit welding. Macro- and micro-structure of welds. Solid-phase bonding, electron beam, laser welding. Design of a welding process. Related laboratory work.

**465. Failure Analysis and Prevention**

Spring. 4(3-3) MMM 211, MMM 215, MMM 250.

Modes and causes of failures of mechanical components. Analysis illustrated through student projects requiring integration of knowledge from several areas.

**476. Alloy Development and Design**

Winter of even-numbered years. 3(3-0) MMM 360 or concurrently.

Fundamental principles which determine the structure and application of ferrous and non-ferrous alloys. Economic analysis of alloy development.

**480. Process Metallurgy**

Winter. 3(3-0) MMM 330.

Metallurgy of iron, steel, and principal non-ferrous metals. Gases in steel. Reduction and oxidation, slag-metal reaction. Kinetics of heterogeneous reactions. Material and energy balances.

**481. Powder Technology**

Spring of even-numbered years. 3(3-0) MMM 250.

Characteristics of metal powders. Basic principles of compacting. Porous and dense products. Micro-structures. Factors affecting physical and mechanical properties of powder blending, compacting, sintering. Relationship between sintering process and properties of powder products.

**499. Senior Research and Design Project**

Fall, Winter, Spring, Summer. 2 or 3 credits. May reenroll for a maximum of 9 credits. Approval of department.

Investigation on subject approved by a faculty member. Results to show student's ability to solve problems pertaining to metallurgy and materials science. Regular conferences and final examination.

**800. Special Problems**

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

Individualized reading and research compatible with the student's interest and ability.

**801. Advanced Dynamics**

Spring of even-numbered years. 4(4-0) MMM 306.

Principles of classical dynamics for particle and rigid body systems. Lagrangian and Hamiltonian methods. Applications to engineering problems.

**805. Strain and Motion Measurement**

Spring. 4(3-3) Graduate students or approval of department.

Resistance strain gages and accelerometers are examined in detail with particular regard to the analysis and design of the whole measuring system. Student project involving transducer design. Other motion measurement techniques.

**806. Optical Methods of Metrology**

Winter of even-numbered years. 4(3-3) Graduate students or approval of department.

Measurement of dimensions, motion, strain by precise optical methods including holography, speckle interferometry, Moire, photoelasticity, coherent optical processing, model analysis, brittle and photoelastic coatings, classical interferometry. Necessary optics theory presented.

**809. Finite Element Method**

Fall, Winter, Spring. 4(4-0) Approval of department. Interdepartmental with Civil Engineering and the Department of Agricultural Engineering.

Theory and application of the finite element method to the solution of continuum type problems in heat transfer, fluid mechanics and stress analysis.

**810. Continuum Mechanics**

Fall, Summer. 4(4-0) MMM 211; MTH 421 concurrently or approval of department.

Stress, deformation and rate-of-deformation tensors. Balance of mass, momentum, and energy. Field equations. Examples of constitutive equations. Selected special solutions in elasticity and Newtonian fluids.

**813. Theory of Elasticity I**

Winter. 4(4-0) MMM 810; MTH 422 or approval of department.

Fundamentals of linear elasticity. Solution of plane elasticity problems. St. Venant bending and torsion. Basic singular solutions. Variational methods.

**814. Mechanics of Composite Materials I**

Winter of odd-numbered years. 3(3-0) MMM 810, MMM 813 or concurrently.

Composite materials and their applications. Anisotropic elasticity theory. Macromechanics and micromechanics of composites. Applications in the mechanics of composite structures.

**815. Advanced Strength of Materials**

Fall, Summer. 3(3-0) MMM 411.

General theory of torsion, unsymmetrical bending, shear flow. Curved beams. Thick-walled cylinders. Beams on elastic foundations. Bending of plates.

**817. Plasticity**

Spring of odd-numbered years. 4(4-0) MMM 810; MTH 422 or approval of department.

Yield conditions, stress-strain relations, plastic potential, hardening theories; torsion, bending, thick-walled spherical and cylindrical shells under internal pressure; plane strain of perfectly plastic material.

**820. Energy Methods in Applied Mechanics**

Fall of odd-numbered years. 3(3-0) MTH 422 or approval of department.

Energy and variational formulations in solid mechanics. Approximate methods (Ritz, Galerkin) based on energy approach. Applications to vibration and stability problems.

**823. Theory of Vibrations I**

Fall. 4(4-0) M E 455. Interdepartmental with and administered by the Department of Mechanical Engineering.

Discrete and continuous 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**

(MMM 920.) Winter of odd-numbered years. 4(4-0) MTH 422; M E 823 or approval of department. Interdepartmental with the Department of Mechanical Engineering.

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. Thermodynamics of Solids**

Fall. 3(3-0) MMM 330 or approval of department.

Mathematical tools: Jacobians, Lagrange multipliers. Thermodynamic functions and laws, phase transformations, thermoelastic solids, crystal defects, surfaces and interfaces, solution thermodynamics, ideal and regular solution models.

**832. Electron Microscopy**

Spring. 4(3-3) MMM 430 or approval of department.

Theory of image formation in electron microscopy and intensity of electron diffraction. Transmission and replica microscopy.

**851. Modern Ceramic Materials II**

Winter. 3(3-0) MMM 850.

Properties of ceramic materials with specific reference to mechanical, optical, electrical, magnetic and thermal properties.

**852. Modern Ceramic Materials III**

Spring. 3(3-0) MMM 851.

Applications of ceramic materials. Glass-ceramics, nuclear fuel elements, hot-pressed translucent oxides, pre-stressed ceramics, ceramic coating, pyrolytic materials.

**853. Advanced Topics in Oxidation and Corrosion**

Winter of even-numbered years. 3(3-0) MMM 431 or approval of department.

Effects of metallurgical and environmental factors on the kinetics of aqueous and solution of electrochemical corrosion and solvent-less metal redox reactions.

**861. Theory of Metals**

Fall of odd-numbered years. 3(3-0) MMM 825.

Metallic bonding, wave aspects of electrons, Schroedinger equation, free-electron model, zone theory of metals, Brillouin zones, band structure, fermi surfaces, electrical and thermal conductivity, specific heat, magnetism, superconductivity.

**863. Advanced Rate Theory and Diffusion**

Fall of even-numbered years. 3(3-0) MMM 825 or approval of department.

Theory of thermal activation and rate processes, mathematical description of diffusion, atomistic theory of diffusion, diffusion in alloys, kinetics of phase transformations, interface migration, and oxidation.

**Description — Metallurgy, Mechanics, and Materials Science  
of  
Courses**

**871. Advanced Physical Metallurgy**  
*Spring of even-numbered years. 3(3-0)*  
MMM 825 or approval of department.

Quasichemical theory of alloy phases, crystal defects, ordering and second order transitions, thermal effects, surface tension, solid state reactions, nucleation, recovery, recrystallization, grain growth, crystallographic transformations, solidification, interfaces.

**872. Advanced Mechanical Metallurgy**  
*Spring of odd-numbered years. 3(3-0)*  
MMM 825 or approval of department.

Dislocation-obstacle interactions, thermally-activated dislocation motion, recovery and recrystallization, deformation of polycrystals, Taylor-theory, deformation and recrystallization textures, dynamic effects, high-temperature deformation, radiation effects.

**885. Seminar**  
*Fall, Winter, Spring. 1(1-0) May reenroll for a maximum of 3 credits. MMM graduate student.*

Detailed library investigation of a specialized aspect of materials science or presentation of own research projects. Participation generally required each term of residence.

**890. Selected Topics**  
*Fall, Winter, Spring, Summer. 3(3-0)*  
*May reenroll for a maximum of 18 credits if a different topic is taken. Approval of department.*

A newly developing area in metallurgy, mechanics, or materials science selected by the department for offering each term. Information on the specific topic to be covered should be obtained from the department office before registration.

**899. Master's Thesis Research**  
*Fall, Winter, Spring, Summer. Variable credit. Approval of department.*

**900. Special Problems**  
*Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 6 credits. Approval of department.*

Individualized reading and research compatible with the student's interest and ability.

**909. Elastic Thin Shells**  
*Spring. 4(4-0) MMM 815 or C E 804 or approval of department; MTH 421. Interdepartmental with and administered by Civil Engineering.*

Elements of differential geometry, membrane theory of shells, Pucher's stress function, deformation and bending of shells of revolution and shallow shells.

**911. Theory of Elastic Stability**  
*Winter of odd-numbered years. 4(4-0)*  
MMM 815 or approval of department.

Theory and methods of determining buckling strength and post-buckling behavior of bar, plate and shell elements and of elastic systems.

**912. Theory of Plates**  
*Winter. 4(4-0) MMM 815 or C E 804 or approval of department; MTH 422. Interdepartmental with Civil Engineering.*

Bending of thin elastic plates with various shapes and boundary conditions; application of energy principles and approximate methods of solution; thick plates; large deflection theory; sandwich plates.

**914. Theory of Elasticity II**  
*Spring of odd-numbered years. 3(3-0)*  
MMM 813 or approval of department.

Further topics in linear elasticity including complex variable solutions, elastodynamics, variational principles, St. Venant's principle, anisotropic material behavior.

**915. Theory of Elasticity III**  
*Spring of even-numbered years. 3(3-0)*  
MMM 813 or approval of department.

Introduction to finite elasticity. Kinematics of large deformations, kinetics, constitutive relation - general theory and particular models, solution of basic problems. Non-uniqueness. Singular fields near crack-tips. Material stability.

**916. Fracture Mechanics**  
*Fall of even-numbered years. 3(3-0)*  
MMM 813.

Brittle and ductile fracture in structural materials. Elastic stress fields near cracks, theories of brittle fracture, elastic fracture mechanics. Elastic-plastic analysis of crack extension. Plastic instability. Running cracks.

**917. Fatigue of Engineering Structures**  
*Fall of odd-numbered years. 3(3-0)*  
MMM 411 or approval of department.

Theories of cyclic deformation and fatigue. Macro and micro failure. Notched components. Combined loading. High temperature fatigue, environmental effects. Case studies.

**918. Theory of Viscoelasticity**  
*Winter of even-numbered years. 3(3-0)*  
MMM 810; MTH 422 or approval of department.

Fundamental linear viscoelastic stress-strain relations. Model representation. Three dimensional and general deformation laws. Correspondence principle. Quasi-static, dynamic and buckling problems.

**940. Modern Problems in Materials Science**  
*Fall, Spring. 3(3-0) May reenroll for a maximum of 9 credits. Approval of department.*

Current field of research in ceramics, martensitic transformations, oxidation and corrosion, electron microscopy, recrystallization and textures.

**941. Crystal Defects**  
*Winter of even-numbered years. 3(3-0)*  
MMM 825 or approval of department.

Defects in thermodynamic equilibrium. Vacancies. Interstitials, color centers. Role of defects in diffusion, radiation damage. Geometrical and elastic properties of dislocations, dislocation reactions, grain boundary structures and kinetics.

**942. Advanced Topics in Phase Transformations**  
*Winter of odd-numbered years. 3(3-0)*  
MMM 825 or approval of department.

Precipitation and ripening, gradient energy term, spinodal decomposition, surface and strain effects, allotropic and polytropic transformations, martensitic transformations, electronic effects, charge density waves, thermoelastic and shape memory alloys.

**999. Doctoral Dissertation Research**  
*Fall, Winter, Spring, Summer. Variable credit. Approval of department.*

**MICROBIOLOGY AND  
PUBLIC HEALTH MPH**

**College of Human Medicine  
College of Natural Science  
College of Osteopathic Medicine  
College of Veterinary Medicine**

**200. Elementary Microbiology**  
*Fall, Winter. 4(3-2) Three terms of Natural Science. Primarily for majors outside the College of Natural Science.*

Description of bacteria and related forms of microorganisms, their growth and nature, their application in industry, and their control in public health.

**234. Elementary Medical Microbiology**  
*Fall. 5(4-4) CEM 130, B S 211, approval of department.*

Survey of immunology and microbiology with emphasis on pathogenic microorganisms, antimicrobial agents, and laboratory diagnosis.

**301. Introductory Microbiology**  
*Fall, Spring, Summer. Given at W. K. Kellogg Biological Station Summer term. Fall, Spring: 3(3-0) Summer: 3 credits. CEM 242, CEM 244 or BCH 200.*

Fundamentals of microbiology. Ranges of cell structure and activities; nutrition, growth, and importance of major microbial groups.

**302. Introductory Microbiology Laboratory**  
*Fall, Spring, Summer. Given at W. K. Kellogg Biological Station Summer term. Fall, Spring: 2(0-4) Summer: 2 credits. MPH 301 or concurrently.*

Methodology of microbiology including microscopy, staining, asepsis, cultural media and quantification.

**303. Microbiology I: General**  
*Fall. 4(4-0) BCH 451 or concurrently.*

Principles of microbiology emphasizing cell structure and function, metabolism, growth and death, differentiation, diversity, and microbial interaction.

**304. General Microbiology Laboratory I**  
*Fall. 3(1-5) MPH 303 or concurrently.*

Techniques and procedures of general microbiology emphasizing the isolation and identification of bacteria, the qualitative aspects of growth and death, and bacterial interactions.

**306. General Microbiology Laboratory II**  
*Spring. 3(1-5) MPH 304.*

Continuation of MPH 304 with emphasis on immunologic and genetic techniques and procedures.

**310. Food Safety and Microbiology**  
*Fall. 4(3-3) CEM 143 or concurrently or approval of department. Not open to students with credit in FSC 440. Interdepartmental with and administered by Food Science.*

Effects of food handling, preparation and service on food safety. Microorganisms in foods, sanitation, food borne disease and food service regulations.

**400H. Honors Research**  
*Fall, Winter, Spring, Summer. 2 credits. May reenroll for a maximum of 8 credits. Approval of department.*

A four-term research project with thesis.