

**METALLURGY, MECHANICS
AND MATERIALS
SCIENCE**

MMM

College of Engineering

- 160. Engineering Communications**
(EGR 160.) Fall, Winter, Spring. 4(3-4)
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.
- 201. Introduction to Engineering Mechanics**
Winter. 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.
- 205. Mechanics I**
Fall, Winter, Spring, Summer. 4(4-0)
MTH 215.
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.
- 211. Mechanics of Deformable Solids**
Fall, Winter, Spring, Summer. 4(4-0)
MMM 205; MTH 310 concurrently, MMM 215 concurrently.
Deformable solids, stress and strain, principal axes, material behavior (elastic, plastic, viscoelastic, temperature dependent). Boundary value problems, torsion, beams. Instability, columns.
- 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**
(370.) Fall, Winter, Summer. 4(3-3)
CEM 152.
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.
- 280. Manufacturing Processes**
(M E 280.) Fall, Spring. 3(2-3)
An introduction to the materials and processes used in manufacturing, to convert ideas into products, machines, and structures for the use of people. Extensive use is made of audiovisual techniques. Field trips required.
- 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. Gibb's phase rule. Solutions. Quasichemical theory of solutions. Thermodynamics of surfaces and interfaces. Thermodynamics of defects.
- 340. Computer Aided Manufacturing**
(M E 341.) Spring. 4(3-2) CPS 115 or CPS 120 or CPS 251 or LBS 124. Interdepartmental with the Department of Computer Science.
APT and COMPACT numerical control languages. Group technology and computer-aided process planning. Introduction to manufacturing robotics.
- 350. Mechanical Properties of Materials I**
Fall. 3(3-0) MMM 211, MMM 215, MMM 250.
Mechanical properties in tension, compression direct shear, torsion, flexure. True stress-strain. Cold work constants. Hardness, impact, fatigue properties. Effect of temperature on mechanical behavior, creep, stress rupture.
- 351. Mechanical Properties of Materials II**
Winter. 3(3-0) MMM 350.
Mechanism of slip, slip systems, critical resolved shear stress, mechanical twinning. Deformation in polycrystalline materials. Impurity effect and yield point phenomenon. Dislocation reactions, multiplication, movement under force.
- 352. Mechanical Property Laboratory**
Fall. 1(0-3) MMM 350 or concurrently.
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.
- 404. Dynamics of Mechanical Systems**
Fall. 3(3-0) MMM 306.
Principles of Newtonian dynamics. Lagrangian dynamics of rigid-body systems. Introductory orbital mechanics. Euler's dynamical equations and gyroscopic motion. Engineering applications.
- 411. Mechanics of Deformable Solids II**
Spring. 3(3-0) MMM 211.
Continuation of MMM 211. Unsymmetrical bending, curved beams, torsion of non-circular shapes, shear center, beam columns. Introduction to energy theorems with applications to determinate and indeterminate beams, and rings.
- 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.
- 430. X-Ray Crystallography**
Spring. 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 of Metals**
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**
(M E 442.) Spring. 3(3-0) MMM 280, EGR 390.
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.
- 452. Diffusion in Metals and Alloys**
Spring of odd-numbered years. 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**
Spring of even-numbered years, Winter of odd-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.
- 456. Strengthening Mechanisms in Solids**
Winter. 3(3-0) MMM 351.
Theory of alloy strengthening. Role of solute distribution on dislocation movement in binary and complex alloys. Multiphase aggregate strengthening. Composite materials and unidirectionally solidified eutectics. Thermomechanical processing and strength. High temperature effects.
- 461. Heat Treatment and Properties of Ferrous Alloys**
Spring. 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 diagrams, carburizing, case hardening. Design of a heat-treating process for an alloy.

- 462. Metal Fabrication**
Spring, 3(3-0) MMM 350, MMM 360.
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, 3(3-0) MMM 350 or concurrently.
Theory and applications of arc, gas, resistance, and Thermit welding. Examinations of micro- and macro-structure of welds and adjacent areas. Solid-phase bonding, electron beam, laser welding. Design of a welding process.
- 465. Failure Analysis and Prevention**
Winter, 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.
- 480. Process Metallurgy**
(460.) 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 Metallurgy**
Spring of even-numbered years, 3(3-0) MMM 360.
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 8 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 Engineering Mechanics I**
Fall, Summer, 3(3-0) MMM 306.
Principles of classical dynamics; Lagrangian equations for electromechanical systems; Hamiltonian formulation; matrix treatment of vibrations.
- 802. Advanced Engineering Mechanics II**
Winter, 3(3-0) MMM 801.
Rigid-body mechanics; the gyroscope; canonical transformations; Hamilton-Jacobi theory; engineering applications of advanced mechanics.
- 805. Strain and Motion Measurement**
Spring, Summer, 4(3-3) 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 Strain Measurement**
Winter of even-numbered years, 4(3-3) Approval of department.
Whole-field techniques such as photoelasticity, photoelastic coatings, Moire techniques, and brittle coating. Interferometers and model analysis. Necessary theory of optics is presented.
- 809. Finite Element Method**
Fall, 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. Introduction to the Mechanics of a Continuous Medium**
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 by use of Airy's stress functions, complex-function theory, variational methods, and finite differences.
- 815. Advanced Strength of Materials I**
Fall, Summer, 3(3-0) MMM 211.
Elasticity, energy methods, general bending of straight bars, curved beams, shear center, torsion.
- 816. Advanced Strength of Materials II**
Winter, 3(3-0) MMM 815; MTH 215.
Beams on elastic support, beam columns, axially symmetric stress distribution, symmetrical bending of circular plates, introduction to theory of elasticity.
- 817. Plasticity**
Spring, 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.
- 823. Theory of Vibrations I**
Fall, 4(4-0) ME 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.
- 832. Electron Microscopy**
Spring, 4(3-3) MMM 831 or approval of department.
Theory of image formation in electron microscopy and intensity of electron diffraction. Transmission and replica microscopy.
- 850. Modern Ceramic Materials I**
Fall, 3(3-0) CEM 462; PHY 840; or approval of department.
Crystalline macrostructure and microstructure of ceramics and glasses; dependence of microstructure on amounts, size, shape, and distribution of phases; modification of microstructure by control of nucleation and growth; composite materials.
- 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.
- 860. Theoretical Metallurgy I**
Fall, 3(3-0) MMM 342.
Metallurgical thermodynamics, introduction to statistical thermodynamics, kinetics of metallurgical processes.
- 861. Theoretical Metallurgy II**
Winter, 3(3-0) MMM 860.
Introduction to quantum theory of metals, physical properties of metals and alloys.
- 876. Nonferrous Process Metallurgy**
Winter, 3(3-0) MMM 462.
Stoichiometric material and heat balance calculation in nonferrous extractive metallurgy.
- 881. Metals and Alloys II**
Winter, 3(3-0) MMM 850.
Similar to MMM 845, but with reference to non-ferrous alloys.
- 885. Seminar**
Fall, Winter, Spring, 1 credit. MMM 899 concurrently.
- 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

Fall 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.

915. Theory of Elasticity II

Spring. 3(3-0) MMM 813 or approval of department.

Saint-Venant bending and torsion. Problems in three-dimensional linear elasticity using the Galerkin vector and Neuber-Papkovich functions.

918. Theory of Viscoelasticity

Fall 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.

920. Theory of Vibrations II

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.

921. Theory of Vibrations III

Spring of odd-numbered years, Summer. 4(4-0) MMM 920 or approval of department. Interdepartmental with the Department of Mechanical Engineering.

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

999. Doctoral Dissertation Research

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

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, Winter, Spring. 3(3-0) 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. 2(0-4) 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

Winter. 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) Juniors; CEM 132 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.

405. Microbiology II: Immunobiology/Cell Biology

(427.) Winter. 4(4-0) MPH 303; BCH 452 or concurrently. Students may not receive credit in both MPH 405 and MPH 462.

Cell biology of eukaryotic cells with immune system as model. Emphasize structure-function relationships in subcellular organelles, antigen metabolism and regulatory mechanisms of immune responsiveness.

406. Medical Mycology

Fall, Spring. 4(2-6) BOT 402 or approval of department. Interdepartmental with and administered by the Department of Botany and Plant Pathology.

Characteristics, habits, and laboratory identification of fungus diseases infecting humans. Emphasis on laboratory techniques and morphological characteristics of the various mycoses.

407. Microbiology III: Microbial Genetics

(423.) Spring. 4(4-0) MPH 405; BCH 453 or concurrently.

Genetics and molecular biology of bacteria and viruses with emphasis on the genetic principles developed from their study.

413. Animal Cells and Viruses

Fall. 3(3-0) MPH 407.

Basic features of animal cell structure and function, and of animal viruses as tools to understand eukaryotic gene expression, as pathogens, and as examples of diversity and divergence with cellular mechanisms.

416. General Parasitology

Fall. 3(3-0) B S 210, B S 211, B S 212 or LBS 141.

Life history, host-parasite relationships (including physiology, immunology, immunopathology and pathology) and epidemiology of selected groups and species of protozoan, trematode, cestode and nematode parasites.

417. General Parasitology Laboratory

Fall. 2(0-4) MPH 416 or concurrently or approval of department.

Identification and life histories of representative species of major groups of animal parasites. Selected concepts of host-parasite associations will be tested experimentally.

420. Biology of Animal Parasites

Summer. 6 credits. B S 212 or approval of department. Given at W. K. Kellogg Biological Station. Interdepartmental with the departments of Fisheries and Wildlife, and Zoology.

Parasitism of animals by protozoa, helminths and arthropods with emphasis on the interrelationships of host-parasite associations with the natural environments.

425. Microbial Ecology

Spring. 3(3-0) MPH 301 or approval of department. MPH majors must enroll concurrently in MPH 425A.

Microbial activities in natural ecosystems; their association with plants and animals, and their transformations of carbon, nitrogen and sulfur in soil and aquatic habitats.

425A. Microbial Ecology Recitation

Spring. 1(1-0) MPH 425 concurrently.

Quantitative aspects of microbial ecology.

429. Host-Parasite Relationships

Winter. 3(3-0) MPH 407, MPH 413.

Molecular basis of microbial virulence determinants and their role in overcoming mechanisms of host defense.

437. Introductory Medical Parasitology

Fall. 5(3-5) B S 210, B S 211, B S 212.

Primarily for Medical Technology students.

Biology of protozoan, helminth, and arthropod infections of humans. Laboratory diagnosis of these infections.

MICROBIOLOGY AND PUBLIC HEALTH

MPH

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