930. *Seminar*

Fall, Winter, Spring. 1 credit. May re-enroll for a maximum of 3 credits in master's program; 6 credits in doctoral program. Open to graduate students of all colleges and departments.

Recent developments in space orbit theory, theory of space propulsion, magnetohydrodynamics, re-entry phenomena, ionosphere, space radiation phenomena, design of space vehicles, and developments in the field pertinent to space technology such as external environmental conditions, internal environmental conditions, effects upon space vehicle construction, etc.

941. *Advanced Gas Dynamics II*

Fall of odd-numbered years. 3(3-0) 841.

Transonic flows, blunt bodies in supersonic flows, three-dimensional supersonic flows, hodograph methods, characteristics, unsteady phenomena, physical gas dynamics.

942. *Viscous Fluids*

Fall of even-numbered years. 3(3-0) MMM 810 or CHE 841.

Exact solutions of Navier-Stokes equations, i.e., Oscillatory Motion, Laminar Jet, Converging Channel, etc.; Hydrodynamic Stability including free convection, surface tension, gravitational and free-surface instabilities, and Tollmien-Schlichting waves.

952. *Slip and Free (Newtonian) Molecular Flows*

Spring. 3(3-0) 412, 432.

Distribution function; Boltzmann equation; solutions of Enskog-Burnett, Grad; slip flow; drag coefficient; heat transfer. Free molecule flow; elastic and inelastic reflections; flow around bodies; resistance coefficient; heat; oblation; meteors.

953. *Plasma Dynamics (Magneto-Gas Dynamics)*

Winter. 3(3-0) 432; PHY 467.

Fundamental equations of hydrodynamics; Maxwell equations; continuum; channel flow; boundary layer; shocks; Alfven wave propagation; one and two fluid theories; discrete particle approach; plasma oscillations; flow around bodies and in nozzles; space propulsion systems.

954. *Ion Flow Dynamics*

Spring. 3(3-0) 953.

Continuation of 953 as applied to the ion flow; extension of the neutral flow turbulence into electromagnetic turbulence, and method of characteristics applied to the ion flow dynamics.

999. *Research*

(EGR 999.) Fall, Winter, Spring, Summer. Variable credit. Approval of department.

MEDICAL TECHNOLOGY M T

College of Human Medicine

College of Veterinary Medicine

201. *Medical Technology*

Fall. 1(1-0) Approval of school.

Relationship of medical technology to medicine and research, and the necessary interaction with other paramedical sciences.

401. *Seminar in Medical Technology*

Fall. 1 credit. Seniors.

Acquaints students with the operation and administration of a hospital, the philosophy and understanding of the entire profession of medical technology.

MEDICINE MED

College of Human Medicine

590. *Special Problems in Medicine*

Fall, Winter, Spring. Summer. 1 to 6 credits. May re-enroll for a maximum of 12 credits. Human Medicine students.

Each student will work under direction of a staff member on an experimental, theoretical or applied problem.

METALLURGY, MECHANICS AND MATERIALS SCIENCE MMM

College of Engineering

205. *Mechanics I*

Fall, Winter, Spring. 4(4-0) MTH 214 or concurrently.

Vector description of forces, moments, and motion. Statics. Dynamics of particles and particle systems. Energy and momentum principles. Stability of equilibrium.

206. *Mechanics II*

Fall, Winter, Spring. 4(4-0) 205; MTH 215 or concurrently.

Dynamics of rigid bodies in general motion, plane motion, rotation, statics, variational methods.

211. *Mechanics of Deformable Solids*

Fall, Winter, Spring, Summer. 4(4-0) 205 or statics; MTH 215.

Deformable solids, stress and strain, principal axes, material behavior (elastic, plastic, viscoelastic, temperature dependent). Boundary value problems, torsion, beams. Instability, columns.

215. *Materials Testing Laboratory*

Fall, Winter, Spring, Summer. 1(0-3)

Physical properties of engineering materials, resistance to primary types of static loading.

230. *Introduction to Materials Science*

Fall. 4(4-0) Sophomores.

A qualitative survey of the atomic and molecular structure of materials and their related mechanical, thermal, electrical, and magnetic properties.

304. *Dynamics*

Fall. 4(5-0) Statics; MTH 215 or concurrently.

Dynamics of particles and rigid bodies for those students who have had statics.

320. *Analytical Mechanics I*

Fall. 3(3-0) MTH 215; PHY 289.

Measures of point motion, indicial notation, vector space and time transformations. Newton's, Lagrange's and Hamilton's equations. Motions of point objects; limiting wave forms.

321. *Analytical Mechanics II*

Winter. 3(3-0) 320.

Schrodinger's equation. Particle motions in various potentials; hydrogen-like atoms and molecules. Continuum models of particle systems; tensor properties, rigid and elastic solids, transfer of heat and electricity, flow relations.

322. *Analytical Mechanics III*

Spring. 3(3-0) 321.

Quantum and statistical models of particle systems; the Maxwell-Boltzmann, Einstein-Bose and Fermi-Dirac distributions; analysis of ideal atomic, electron and photon gases; properties of dense gases and liquids; thermal, elastic and electrical properties of crystals.

340. *Materials Chemistry I*

(440.) Fall. 4(4-0) CEM 153.

MMM 340, 341 and 342 present an integrated theory of chemical properties and phase transformations in metals and other engineering materials. Classical thermodynamics and thermochemistry of solids and solid solutions.

341. *Materials Chemistry II*

(441.) Winter. 4(4-0) 340.

Homogeneous and heterogeneous equilibria in solids; diffusion and solid-state reactions; nucleation phenomena. Metallurgy and electrochemistry. Theory of the periodic relations among the properties of the elements.

342. *Materials Chemistry III*

(442.) Spring. 4(4-0) 341.

Continuation of 341. The influence of atomic properties in the formation of alloys and solid compounds. Cohesive forces and bonding in solids. Introduction to the statistical theory of the properties of engineering materials.

360. *General Metallurgy*

Fall. 4(4-0) CEM 153 or approval of department.

Properties of metals, states of heterogeneous equilibrium and non-equilibrium, deformation processes.

361. *Physical Metallurgy I*

Winter. 4(4-0) 360.

Application of fundamental metallurgical theory to nonferrous metals and alloys.

362. *Physical Metallurgy II*

Spring. 4(4-0) 360.

Carbon and alloy steels: composition, influence of heat treatments, etc.

370. *Metals and Alloys I*

Winter. 4(3-3)

Principles of physical metallurgy applied to engineering metals and alloys.

371. *Metals and Alloys II*

Spring. 3(3-0) 370.

Continuation of 370.

372. *Metals and Alloys III*

Fall. 3(3-0) 371.

Continuation of 371.

380. *Metallurgy Laboratory I*

Fall. 1(0-3) 360 or concurrently

First of an integrated sequence of laboratory courses designed to illustrate the parallel theory courses.

381. *Metallurgy Laboratory II*

Winter. 1(0-3) 380; 361 concurrently.

Continuation of 380.

382. *Metallurgy Laboratory III*

Spring. 1(0-3) 381; 362 concurrently.

Continuation of 381.

400. *Special Problems*

Fall, Winter, Spring, Summer. 1 to 3 credits. May re-enroll for a maximum of 9 credits. Approval of department.

Individualized readings and research for students of high intellectual promise.

414. Experimental Solid Mechanics
Fall. 4(3-3) 211.

Fundamental concepts and current technology for static and dynamic measurement of strain and displacement. Three main topics are resistance strain gages, photoelasticity, and accelerometers. Other topics include displacement transducers, brittle coatings, Moire patterns, and holography.

430. X-Ray Metallography
Spring. 4(3-3) 342 or concurrently; or approval of department.

General properties of X-rays, elementary crystallography, interaction of X-rays with matter, application of X-ray diffraction to materials problems.

440. Color Technology in Materials Science
Winter. 3(3-0) Approval of department; 441 concurrently for engineering students.

Color in art and technology; light and its interaction with colored materials; light sources and illuminants; color notation and classification; colored materials.

441. Color Technology Theory
Winter. 1(1-0) 342 or approval of department; 440 concurrently.

Mathematical treatment of color technology theory.

450. Physical Properties of Materials I
Fall. 4(4-0) 342 or approval of department.

Structure of solids; crystallography phenomenological properties of solid materials.

451. Physical Properties of Materials II
Winter. 4(4-0) 450.

Quantum mechanics of crystals, electrons in solids, electrical, magnetic and thermal properties of materials.

452. Physical Properties of Materials III
Springs. 4(4-0) 451 or PHY 459.

Dislocation interaction and the mechanical properties of materials, diffusion controlled and diffusionless phase transformations in metals and alloys and topics of current interest in materials science.

460. Metallurgical Engineering I
Fall. 4(3-2) 361, 362.

Melting and casting practice, stoichiometry, refining operations, furnaces and refractories, ingot practice. Seminar included.

461. Metallurgical Engineering II
Winter. 4(3-2) 361, 362.

Commercial heat treating of metals and alloys. Furnace design and calculation. Special methods such as carburizing, cyaniding, etc. Seminar included.

465. Extractive Metallurgy
Fall. 4(3-2) 361, 362, or approval of department.

Mineral dressing, beneficiation, ore reduction and refining of iron and steel, aluminum, copper, lead, zinc, and the minor metals.

470. Cast Metals
Fall, Winter. 4(4-0) 362 or 372.

Liquid metals and solidification with special reference to metals and alloys to be used in the cast condition.

475. Alloy Design
Spring. 4(4-0) 361, 362, or approval of department.

Alloys designed for special purposes such as magnetic materials, materials for high- and low-temperature services, and tool materials.

480. Metallurgy Laboratory IV
Fall. 1(0-3) 382.

Continuation of 382.

481. Metallurgy Laboratory V
Winter. 1(0-3) 480.

Continuation of 480.

482. Metallurgy Laboratory VI
Spring. 1(0-3) 481.

Continuation of 481.

800. Special Problems
Fall, Winter, Spring. 1 to 6 credits. May re-enroll 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) 206 or 320.

Principles of classical dynamics; Lagrangian equations for electromechanical systems; Hamiltonian formulation; matrix treatment of vibrations.

802. Advanced Engineering Mechanics II
Winter. 3(3-0) 801.

Rigid-body mechanics; the gyroscope; canonical transformations; Hamilton-Jacobi theory; engineering applications of advanced mechanics.

803. Advanced Engineering Mechanics III
(820.) Spring. 3(3-0) Approval of department.

Variational methods for point objects; wave motion. Schrodinger's equation and particle motions in potential wells. Continuum, quantum and statistical models of particle systems.

810. Introduction to the Mechanics of a Continuous Medium
Fall, Summer. 4(4-0) 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) 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.

814. Experimental Mechanics II
Fall. 4(3-3) 211.

Methods of evaluation of stress fields and structural strength, mechanical model analysis, photoelasticity, Moire methods, brittle coatings.

815. Advanced Strength of Materials I
Fall, Summer. 3(3-0) 211.

Elasticity, energy methods, general bending of straight bars, curved beams, shear center, torsion.

816. Advanced Strength of Materials II
Winter. 3(3-0) 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) 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) M E 325. Interdepartmental with and administered by the Mechanical Engineering Department.

Discrete and continuous parameter systems with linear and non-linear characteristics. Variational principles; equations of motion. Matrices, quadratic forms; self-adjoint operators; eigenvalues. Transient and random excitations. Theory developed through physical problems.

831. Advanced X-Ray Metallography
Winter. 3(3-0) Approval of department.

Development of crystallographic space groups, theory of the intensity of diffracted X-rays; Weissenberg method, crystal structure analysis.

832. Electron Microscopy
Spring. 4(3-3) 831 or approval of department.

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

840. Symmetry and the Properties of Crystals
Fall. 3(3-0)

Point-group theory and symmetry in tensor properties of crystals; systematic treatment of properties, e.g., electrical polarization, magnetic induction, pyro-and piezo-electricity, elasticity, transport properties and berefringence.

850. Modern Ceramic Materials
Fall. 3(3-0) CEM 462; PHY 459; 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) 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) 851.

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

860. Theoretical Metallurgy I
Fall. 3(3-0) 342.

Metallurgical thermodynamics, introduction to statistical thermodynamics, kinetics of metallurgical processes.

861. Theoretical Metallurgy II
Winter. 3(3-0) 860.

Introduction to quantum theory of metals, physical properties of metals and alloys.

862. Theoretical Metallurgy III
Spring. 3(3-0) 861.

Imperfection in crystalline solids, dislocation theory and mechanical properties of metals and alloys.

870. Ferrous Physical Metallurgy
Fall. 3(3-0) 342, 362.

Theory of steel hardening and hardenability from nucleation, growth, and shear considerations.

871. Nonferrous Physical Metallurgy
Winter. 3(3-0) 342, 361.

Binary, ternary and complex alloy systems, shear mechanism, recrystallization and grain growth, age hardening, and other diffusion mechanisms.

872. Physical Metallurgy of Alloy Steels
Spring. 3(3-0) 870, 871.

Steels for extreme service conditions.

875. Ferrous Metallurgy
Fall. 3(3-0) 465.

Stoichiometric material and heat balance calculations of the blast furnace, open hearth and electric furnace processes.

876. Nonferrous Process Metallurgy
Winter. 3(3-0) 465.

Stoichiometric material and heat balance calculation in nonferrous extractive metallurgy.

880. Metals and Alloys I
Fall. 3(3-0) 372.

Topics in engineering properties and application of wrought steels for engineers other than metallurgical.

881. Metals and Alloys II
Winter. 3(3-0) 372.

Similar to 845, but with reference to nonferrous alloys.

882. Metals and Alloys III
Spring. 3(3-0) 372.

Similar to 845, but with reference to cast alloys.

885. Seminar
Fall, Winter, Spring. 1 credit. 899 concurrently.

890. Selected Topics
Fall, Winter, Spring, Summer. 3(3-0) May re-enroll 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. Research
(EGR 899.) Fall, Winter, Spring, Summer. Variable credit. Approval of department.

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

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

901. Modern Mathematical Mechanics
Winter of odd-numbered years. 3(3-0) Approval of department.

Application of functional analysis and tensor theory to classical and contemporary problems in dynamics and material properties.

909. Elastic Thin Shells
Summer. 5(5-0) 815 or C E 804 or approval of department; MTH 421. Interdepartmental with and administered by the Civil Engineering Department.

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

910. Nonlinear Continua
Winter of even-numbered years. 4(4-0) 810.

Modern nonlinear theories of continua. Equations of balance and constitutive equations. Topics selected from finite elasticity, nonlinear viscosity and viscoelasticity, electroelasticity. General tensors are introduced and used throughout.

911. Theory of Elastic Stability
Fall of odd-numbered years. 4(4-0 815 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) 815 or C E 804 or approval of department; MTH 422. Interdepartmental with the Civil Engineering Department.

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
(913.) Spring. 3(3-0) 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) 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
(904.) Winter of odd-numbered years. 4(4-0) MTH 422; M E 823 or approval of department. Interdepartmental with the Mechanical Engineering Department.

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

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

933. Advanced Elasticity
Spring of even-number years. 3(3-0) 813, 910 or approval of department.

Selected topics in non-linear elasticity.

935. Mechanics of the Fluid State
Winter of even-numbered years. 3(3-0) 322 or 803.

Boltzmann's equation and the molecular theory of fluids; equations of state of gases, liquids and plasmas; transfer and flow processes.

936. Mechanics of the Solid State
Spring of even-numbered years. 3(3-0) 322 or 803.

Particle calculations of typical mechanical, thermal and electrical properties of crystals. Defect theory; elasticity, plasticity and fracture; phonon and electron scattering.

941. Advanced Topics in Mechanical Metallurgy
Fall of even-numbered years; Winter and Spring of odd-numbered years. 3(3-0) May re-enroll for a maximum of 9 credits.

Various aspects of dislocation theory and its application to the mechanical and physical properties of solids.

942. Advanced Topics in the Kinetics of Phase Transformation
Fall of odd-numbered years; Winter and Spring of even-numbered years. 3(3-0) May re-enroll for a maximum of 9 credits.

999. Research
(EGR 999.) Fall, Winter, Spring Summer. Variable credit. Approval of department.

MICROBIOLOGY AND PUBLIC HEALTH — MPH

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

100. Preview of Microbiology
Winter. 1(1-0)

Science and scientists of microbiology, presented in historical perspective and carried to the forefront of current research. A rigorous preview for students seriously curious about microbiology.

200. Elementary Microbiology
Fall, Winter. 4(3-2) N S 193.

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

234. Introductory Medical Microbiology
Fall. 5(4-4) N S 193.

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

301. Introductory Microbiology
Fall. 4(3-4) B S 212; BCH 200.

Fundamentals of microbiology with emphasis on the comparative nature of the various groups of microorganisms, their distribution and activities.

336. Introductory Medical Parasitology
(309.) Fall. 5(3-6) Medical Technology students, or approval of department.

Biology and laboratory diagnosis of protozoan, helminth, and arthropod infections of man.

400. Bacteriology for High School Science
Summer. 4(4-4) Bachelor's degree and teaching certificate, or approval of department.

Fundamental concepts, experiments, and projects useful in secondary school science courses.

400H. Honors Work
Fall, Winter, Spring, Summer. 1 to 6 credits. May re-enroll for a maximum of 12 credits. Approval of department.

Tutored reading and experimentation.