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 491.

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 Osteopathic 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.

608. *Senior Medical Clerkship*

Fall, Winter, Spring, Summer. 17 credits. Primary clerkship, third year Human Medicine students.

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.

METALLURGY, MECHANICS AND MATERIALS SCIENCE MMM

College of Engineering

205. *Mechanics I*

Fall, Winter, Spring, Summer. 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, Summer. 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 metals, ceramics, and polymers, and the relationship of electronic, molecular, and crystal structure to the physical, 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.

An integrated treatment of the physical chemistry of metals and other engineering materials is presented by 340, 341 and 342. Physicochemical systems; thermodynamics and thermochemistry; equilibrium; solutions and phase equilibrium; electrochemistry; corrosion; reaction kinetics in condensed phases; diffusion; surface phenomena.

341. *Materials Chemistry II*

(441.) Winter. 4(4-0) 340 or approval of department.

Continuation of 340.

342. *Materials Chemistry III*

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

Continuation of 340, 341.

360. *Physical Metallurgy I*

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

Relationship of properties to microstructure as affected by solidification transformations in heterogeneous systems, cold work, recrystallization, and grain growth. Emphasis on the important commercial metals and alloys.

361. *Physical Metallurgy II*

Winter. 4(4-0) 360.

Continuation of 360.

362. *Physical Metallurgy III*

Spring. 4(4-0) 360, 361.

Continuation of 360, 361.

370. *Metals and Alloys I*

Fall, Winter. 4(3-3)

Principles of physical metallurgy applied to engineering metals and alloys.

371. *Metals and Alloys II*

Winter. 3(3-0) 370.

Continuation of 370.

372. *Metals and Alloys III*

Spring. 3(3-0) 371.

Continuation of 371.

380. *Physical 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. Introduction to metallography, pyrometry, and testing of metals.

381. *Physical Metallurgy Laboratory II*

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

Continuation of 380.

382. *Physical 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 reading and research.

404. *Dynamics of Mechanical Systems*

Fall. 3(3-0) 206.

Principles of Newtonian dynamics. Lagrangian dynamics of rigid-body systems. Introductory orbital mechanics. Euler's dynamical equations and gyroscopic notion. Engineering applications.

411. *Mechanics of Deformable Solids II*

Spring. 3(3-0) 211.

Continuation of 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.

413. Applied Solid Mechanics

Winter. 3(3-0) 211.

Methods of solution of problems in elasticity, plasticity and viscoelasticity. One- and two-dimensional mathematical models will be considered.

414. Principles and Techniques of Experimental Solid Mechanics

Spring. 3(3-0) 211.

Fundamental concepts and current technology for static and dynamic measurement of strain and acceleration. Main topics discussed are resistance strain gages, photoelasticity, accelerometers; brittle coatings, Moire patterns, and holography.

430. X-Ray Crystallography

Fall. 4(2-6) 342 or approval of department.

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.

440. Color Technology in Materials Science

Winter. 3(3-0) Approval of department.

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

455. Advanced Physical Metallurgy I

Winter. 3(3-0) PHY 364 or approval of department.

Atomic theory of metals and alloys. Nature of chemical and metallic bonds. Lattice vibration and specific-heat theory. Relation of electron energy bands in metals to cohesion, structure, electrical and magnetic properties.

456. Advanced Physical Metallurgy II

Spring. 3(3-0) 455.

Nature of interfaces. Driving forces and kinetics of phase transformation. Plastic deformation of single crystals and relationship to mechanical properties of metals and alloys. Strengthening mechanisms.

460. Metallurgical Engineering I

Fall. 4(3-2) 362 or approval of department.

Extractive metallurgy. Mineral dressing, beneficiation, and physical processing of ores. Chemical metallurgy of ore reduction. Production of iron and steel, copper, aluminum, magnesium, nickel, lead and zinc. Stoichiometric heat, and material balances. Combustion of fuels.

461. Metallurgical Engineering II

Winter. 4(3-2) 460 or approval of department.

Fluid flow and heat transfer in metallurgical processes. Refractories. Heat-treating furnaces and protective furnace atmospheres. Commercial processes for carburizing, cyaniding, and nitriding.

462. Metallurgical Engineering III

(465.) Spring. 4(3-2) 461 or approval of department.

Mechanical processing of metals. Forming, shaping and fabricating operations. Rolling mills, extrusion presses, forging practice, and welding systems. Powder metallurgy processes. Selection of materials and equipment. Quality control.

470. The Cast Alloys

Winter. 4(4-0) 362, or 372.

Physical metallurgy of the cast alloys. Solidification and transformation. Nucleation and inoculation. Mode of solidification as influencing foundry properties in ferrous and nonferrous alloys. Casting design as related to foundry practice.

475. Alloy Development and Application

Fall. 4(4-0) 361, 362, or approval of department.

Physical metallurgy, development, and applications of special steels and alloys: the high-strength structural steels, machine steels, ultra high-strength steels, maraging steels, corrosion-resistant steels and alloys, high-temperature alloys.

480. Metallurgy Laboratory IV

Fall. 1(0-3) 382.

Continuation of 382.

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.

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

(814.) 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.

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.

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 455. 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.

835. Orthopedic Biomechanics

Fall. 3(3-0) Approval of department.

Basic theories of mechanics with application to orthopedics. Elastic and viscoelastic materials will be considered and experimental demonstrations of tissue response.

840. Symmetry and the Properties of Crystals

Spring. 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 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) 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) 462.

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

876. Nonferrous Process Metallurgy
Winter. 3(3-0) 462.

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
Spring. 4(4-0) 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 Osteopathic Medicine
College of Veterinary Medicine

100. Preview of Microbiology
Winter. 1(1-0) Freshmen and Sophomores only.

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.