Electrochemistry; corrosion; reaction kinetics in chemistry of metals and engineering materials is Thermochemistry, solutions, phase dimensional rigid body dynamics. 341. Materials Chemistry for A A-146 Dynamics of particles and particle systems. 280. An introduction to the materials and processes comparison of experimentation and theory. 211. Mechanics of Deformable Solids Fall, Winter, Spring, Summer. 4(4-0) MTH 215, MTH 215 concurrently, for A, C, E, M E majors. 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(0-0) MTH 211 concurrently. Instrumentation, physical properties of materials, comparison of experiment and theory. 230. Introduction to Materials Science Spring. 4(4-0) Sophomores. A qualitative survey of metals, ceramics, and polymers, and the relationship of electronic, mechanical, chemical, thermal, electrical and magnetic properties. 280. Manufacturing Processes (M E 280) Fall, Winter, Spring, 3(3-3). 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. 4(4-0) MTH 215. Dynamics of particles and particle systems. Energy and momentum principles. Two and three dimensional rigid body dynamics. 341. Materials Chemistry II Winter. 4(4-0) CEM 361 or M E 311. An integrated treatment of the physical chemistry of metals and engineering materials is presented in MTH 341 and MTH 342. Thermochemistry, solutions, phase equilibria; electrochemistry; corrosion; reaction kinetics in liquids and solids; diffusion; surface phenomena. 342. Materials Chemistry III Spring. 4(4-0) MTH 341. Continuation of MTH 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, solid work, recrystallization, and grain growth. Emphasis on the important commercial metals and alloys. 361. Physical Metallurgy II Winter. 4(4-0) MTH 360. Continuation of MTH 360. 370. Metals and Alloys I Fall. Winter. 4(3-3) Approval of department. Structure and properties of unalloyed metals, deformation hardening and annealing, phase diagrams, solid solution hardening, precipitation hardening, martensitic transformation and tempering in iron carbon alloys. 371. Metals and Alloys II Winter. 3(3-0) MTH 370 or approval of department. Plain carbon steels, alloy steels, stainless steels; tool materials; cast irons; non-ferrous physical metallurgy with specific emphasis on copper, aluminum, titanium, magnesium, zirconium alloys. 380. Physical Metallurgy Laboratory I Fall. 1(0-0) MTH 360 or concurrently. First of an integrated sequence of laboratory courses designed to illustrate parallel theory courses. Introduction to metallography, pyrometry, and testing of metals. 381. Physical Metallurgy Laboratory II Winter. 1(0-0) MTH 380; MTH 361 concurrently. Continuation of MTH 380. 382. Physical Metallurgy Laboratory III Spring. 1(0-0) MTH 381. Continuation of MTH 381. 400. Special Problems Fall, Winter, Spring. 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) MTH 306. Principles of Newtonian dynamics. Lagrangian dynamics of rigid-body systems. Introductory orbital mechanics. Euler's dynamical equations and gyroscope notion. Engineering applications. 411. Mechanics of Deformable Solids II Spring. 3(3-0) MTH 311. Continuation of MTH 311. 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. 414. Principles and Techniques of Experimental Solid Mechanics Spring. 3(3-0) MTH 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(3-3) MTH 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 and Appearance of Materials Spring. 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. 450. Introduction to Theoretical Metallurgy Fall. 3(3-0) MTH 370 or approval of department. Mechanism of solidification, segregation, dislocation theory, deformation of metals, role of grain boundaries, failure of materials, physical properties. 455. Advanced Physical Metallurgy I Winter. 3(3-0) MTH 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 to metals to cohesion, structure, electrical and magnetic properties. 456. Advanced Physical Metallurgy II Spring. 3(3-0) MTH 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. 461. Metallurgical Engineering I Winter. 3(3-0) MTH 370 or approval of department. Metallurgical furnaces and refractories. Commercial process for carburizing, cyaniding and nitriding. Ceramic coating on metals, powder metallurgy, composites. 462. Metallurgical Engineering II Spring. 3(3-0) MTH 461, MTH 450 or approval of department. Mechanical processing of metals, rolling, forging, welding, extrusion, machining processes, texture, material selection and equipment, quality control. 465. Mechanical Failure Analysis Spring. 3(3-0) MTH 211, MTH 215, MTH 230 or MTH 370 or approval of department. Modes and causes of failures of mechanical components. Analysis illustrated through student projects requiring integration of knowledge from several areas.
470. The Cast Alloys  
Winter. 4(4-0) MMM 372.  

471. Metals and Alloys III  
(372.) Spring. 3(3-0) MMM 371 or approval of department.  
Experimental methods for physical examination of metals, alloy design, special ferrous and nonferrous alloys, multicomponent eutectics and eutectoids, corrosion, metallic glasses.

475. Alloy Development and Application  
Fall. 4(4-0) MMM 361, 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, managing steels, corrosion-resistant steels and alloys, high-temperature alloys.

480. Extractive Metallurgy  
(460.) Fall. 4(3-2) Approval of department.  
Extractive metallurgy. Mineral dressing, beneficia-

800. Special Problems  
Fall, Winter. Spring 1 to 6 credits. May be repeated for a maximum of 6 credits. Approval of department. Individualized reading and research compatible with the student's interests and ability.

801. Advanced Engineering Mechanics I  
Fall. Summer. 3(3-0) MMM 306.  

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 gage 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 photelasticity, photoelastic coatings. Moiré 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.  
Interdisciplinary 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.  

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

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.  
Bending 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.  

850. Modern Ceramic Materials III  
Fall. 3(3-0) CEM 457: PHY 540; or approval of department.  
Ceramic microstructure and macrostructure of ceramics and glasses; dependence of microscopic properties on amount, 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.  
Introduction to the development of the theory of metal formation, 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.

862. Theoretical Metallurgy III  
Spring. 3(3-0) MMM 361.  
Imperfections in crystal lattices, dislocation theory and mechanical properties of metals and alloys.

875. Ferrous Metallurgy  
Fall. 3(3-0) MMM 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) MMM 467.  
Stoichiometric material and heat balance calculation in nonferrous extractive metallurgy.

880. Metals and Alloys I  
Fall. 3(3-0) MMM 372.  
Topics in engineering properties and application of wrought steels for engineers other than metallurgical.

881. Metals and Alloys II  
Winter. 3(3-0) MMM 372.  
Similar to MMM 845, but with reference to nonferrous alloys.

882. Metals and Alloys III  
Spring. 3(3-0) MMM 372.  
Similar to MMM 845 but with reference to cast alloys.

885. Seminar  
Fall, Winter, Spring. 1 credit. MMM 899 concurrently.
### Courses

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<td>890</td>
<td>Selected Topics</td>
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<td>899</td>
<td>Master's Thesis Research</td>
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<td>Special Problems</td>
<td>Fall, Winter, Spring, Summer 3(3-0)</td>
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<td>909</td>
<td>Elastic Thin Shells</td>
<td>Spring 3(3-0)</td>
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<td>910</td>
<td>Nonlinear Continua</td>
<td>Winter of even-numbered years 3(3-0)</td>
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<td>911</td>
<td>Theory of Elastic Stability</td>
<td>Fall, Winter, Spring, Summer 3(3-0)</td>
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<td>912</td>
<td>Theory of Plates</td>
<td>Winter 3(3-0)</td>
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<td>915</td>
<td>Theory of Elasticity II</td>
<td>Spring 3(3-0)</td>
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<td>918</td>
<td>Theory of Viscoelasticity</td>
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<td>920</td>
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<td>921</td>
<td>Theory of Vibrations III</td>
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<td>Advanced Topics in the Kinetics of Phase Transformation</td>
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<td>999</td>
<td>Doctoral Dissertation Research</td>
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**Microbiology and Public Health - MPH**

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<td>234</td>
<td>Elementary Medical Microbiology</td>
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<td>301</td>
<td>Introductory Microbiology</td>
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<td>302</td>
<td>Introductory Microbiology Laboratory</td>
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<td>310</td>
<td>Food Safety and Microbiology</td>
<td>Fall, Winter, Spring, Summer 3(3-0)</td>
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<td>400</td>
<td>Bacteriology for High School Science</td>
<td>Summer 1(0-4)</td>
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<td>413</td>
<td>General Virology</td>
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<td>420</td>
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<td>422</td>
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**Descriptions - Metallurgy, Mechanics and Materials Science**

- Metallurgy, mechanics, and materials science are selected from finite-dimensional and general deformation laws.
- Interdepartmental with Civil Engineering.
- Elements of differential geometry, membrane theory of shells, packet's stress function, deformation, and bending of shells of revolution and shallow shells.
- Interdepartmental with and administered by 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.
- Interdepartmental with and administered by Civil Engineering.
- Topics selected from finite elasticity, nonlinear viscosity and viscoelasticity, viscoelasticity, general tensors are introduced and used throughout.
- Interdepartmental with and administered by Civil Engineering.
- Model representation. Three-dimensional linear elasticity using the Garekin vector and Neuber-Papkovich functions.
- Interdepartmental with Civil Engineering.
- Model representation. Three-dimensional and general deformation laws. Correspondence principle. Quasi-static, dynamic, and buckling problems.
- Interdepartmental with the Department of Mechanical Engineering.
- Interdepartmental with the Department of Mechanical Engineering.