MATERIALS SCIENCE (MLGN)

MLGN500. PROCESSING, MICROSTRUCTURE, AND PROPERTIES OF MATERIALS. 3.0 Semester Hrs.
(II) A summary of the important relationships between the processing, microstructure, and properties of materials. Topics include electronic structure and bonding, crystal structures, lattice defects and mass transport, glasses, phase transformation, important materials processes, and properties including: mechanical and rheological, electrical conductivity, magnetic, dielectric, optical, thermal, and chemical. In a given year, one of these topics will be given special emphasis. Another area of emphasis is phase equilibria. Prerequisite: none. 3 hours lecture; 3 semester hours.

MLGN502. SOLID STATE PHYSICS. 3.0 Semester Hrs.
An elementary study of the properties of solids including crystalline structure and its determination, lattice vibrations, electrons in metals, and semiconductors. 3 hours lecture; 3 semester hours. Prerequisite: PH320.

MLGN505. MECHANICAL PROPERTIES OF MATERIALS. 3.0 Semester Hrs.
(I) Mechanical properties and relationships. Plastic deformation of crystalline materials. Relationships of microstructures to mechanical strength. Fracture, creep, and fatigue. Prerequisite: MTGN348. 3 hours lecture; 3 hours lab; 3/4 semester hours. *This is a 3 credit-hour graduate course in the Materials Science Program and a 4 credit-hour undergraduate-course in the MTGN program.

MLGN510. SURFACE CHEMISTRY. 3.0 Semester Hrs.
Introduction to colloid systems, capillarity, surface tension and contact angle, adsorption from solution, micelles and microemulsions, the solid/gas interface, surface analytical techniques, Van Der Waal forces, electrical properties and colloid stability, some specific colloid systems (clays, foams and emulsions). Students enrolled for graduate credit in MLGN510 must complete a special project.

MLGN512. CERAMIC ENGINEERING. 3.0 Semester Hrs.
(II) Application of engineering principles to nonmetallic and ceramic materials. Processing of raw materials and production of ceramic bodies, glazes, glasses, enamels, and cements. Firing processes and reactions in glass bonded as well as mechanically bonded systems. Prerequisite: MTGN348. 3 hours. lecture; 3 semester hours.

MLGN515. ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS. 3.0 Semester Hrs.
(II) Survey of the electrical properties of materials, and the applications of materials as electrical circuit components. The effects of chemistry, processing, and microstructure on the electrical properties will be discussed, along with functions, performance requirements, and testing methods of materials for each type of circuit component. The general topics covered are conductors, resistors, insulators, capacitors, energy convertors, magnetic materials, and integrated circuits. Prerequisites: PHGN200; MTGN311 or MLGN501; MTGN412/MLGN512,. 3 hours lecture; 3 semester hours.

MLGN516. PROPERTIES OF CERAMICS. 3.0 Semester Hrs.
(II) A survey of the properties of ceramic materials and how these properties are determined by the chemical structure (composition), crystal structure, and the microstructure of crystalline ceramics and glasses. Thermal, optical, and mechanical properties of single-phase and multi-phase ceramics, including composites, are covered. Prerequisites: PHGN200, MTGN311 or MLGN501, MTGN412. 3 semester hours: 3 hours lecture.

MLGN517. THEORY OF ELASTICITY. 3.0 Semester Hrs.
This is a graduate course that builds upon the learning outcomes of Continuum Mechanics course to introduce students the fundamentals of Theory of Elasticity. Introduction is realized through theory development, application examples, and numerical solutions. Learning outcomes from this course would be essential to further studies in visco-elasticity and plasticity. Knowledge from this course will enable students to work on variety of engineering applications in Mechanical, Materials, Aerospace, Civil and related engineering fields. This course is cross-listed with MEGN510.
Course Learning Outcomes

- Recall definitions for indicial notation, transformation rules for tensors, and eigenvalue problems. Tensor algebra and tensor calculus.
- Define, and apply, displacement-strain relationships. Strain measurements using strain gauges and rosettes. Calculate principal strains, maximum shear strain in 3D.
- Establish the definitions, and use, stress tensor, traction vector, normal, and shear tractions. Find stresses at a point on a given plane, principal stresses and max shear stress.
- State the general three-dimensional constitutive law for linear elastic materials. Define material symmetry and the engineering notation stiffness matrix for materials with monoclinic, orthotropic, transversely isotropic, cubic symmetry.
- Define, and apply, the generalized form of Hooke's Law for isotropic materials.
- State, and apply, the field equations for linear isotropic elasticity.
- Write clear and complete boundary condition statement.
- Use the semi-inverse method to find solutions for two dimensional elasticity problems.
- Use the Airy stress function to find solutions for two dimensional elasticity problems.
- Define, and apply, yield theories (von Mises and Tresca) for isotropic solids.
- Use the Prandtl stress function to find solutions for torsional elasticity problems.

MLGN519. NON-CRYSTALLINE MATERIALS. 3.0 Semester Hrs.
(I) An introduction to the principles of glass science and engineering and non-crystalline materials in general. Glass formation, structure, crystallization and properties will be covered, along with a survey of commercial glass compositions, manufacturing processes and applications. Prerequisites: MTGN311 or MLGN501; MLGN512/MTGN412. 3 hours lecture; 3 semester hours.

MLGN530. INTRODUCTION TO POLYMER SCIENCE. 3.0 Semester Hrs.
Chemistry and thermodynamics of polymers and polymer solutions. Reaction engineering of polymerization. Characterization techniques based on solution properties. Materials science of polymers in varying physical states. Processing operations for polymeric materials and use in separations. Prerequisite: CHGN221, MATH225, CHEN357. 3 hour lecture, 3 semester hours.

MLGN531. POLYMER ENGINEERING AND TECHNOLOGY. 3.0 Semester Hrs.
(II) This class provides a background in polymer fluid mechanics, polymer rheological response and polymer shape forming. The class begins with a discussion of the definition and measurement of material properties.

Interrelationships among the material response functions are elucidated and relevant correlations between experimental data and material response in real flow situations are given. Processing operations for polymeric materials will then be addressed. These include the flow of polymers through circular, slit, and complex dies. Fiber spinning, film blowing, extrusion and co-extrusion will be covered as will injection molding. Graduate students are required to write a term paper and take separate examinations which are at a more advanced level. Prerequisite: CRGN307, EGGN351 or equivalent. 3 hours lecture; 3 semester hours.

MLGN535. INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY. 3.0 Semester Hrs.

Equivalent with CBEN435,CBEN535,CHEN435,CHEN535,PHGN435,PHGN535,
(II) Application of science and engineering principles to the design, fabrication, and testing of microelectronic devices. Emphasis on specific unit operations and the interrelation among processing steps. Prerequisite: none. 3 hours lecture; 3 semester hours.

MLGN536. ADVANCED POLYMER SYNTHESIS. 3.0 Semester Hrs.

(II) An advanced course in the synthesis of macromolecules. Various methods of polymerization will be discussed with an emphasis on the specifics concerning the syntheses of different classes of organic and inorganic polymers. Prerequisite: CHGN430, ChEN415, MLGN530. 3 hours lecture, 3 semester hours.

MLGN544. ADVANCED PROCESSING OF CERAMICS. 3.0 Semester Hrs.

A description of the principles of ceramic processing and the relationship between processing and microstructure. Raw materials and raw material preparation, forming and fabrication, thermal processing, and finishing of ceramic materials will be covered. Principles will be illustrated by case studies on specific ceramic materials. A project to design a ceramic fabrication process is required. Prerequisite: MTGN314.

MLGN561. TRANSPORT PHENOMENA IN MATERIALS PROCESSING. 3.0 Semester Hrs.

(II) Fluid flow, heat and mass transfer applied to processing of materials. Rheology of polymers, liquid metal/particles slurries, and particulate solids. Transient flow behavior of these materials in various geometries, including infiltration of liquids in porous media. Mixing and blending. Flow behavior of jets, drainage of films and particle fluidization. Surface-tension-, electromagnetic-, and bubble-driven flows. Heat -transfer behavior in porous bodies applied to sintering and solidification of composites. Simultaneous heat-and-mass-transfer applied to spray drying and drying porous bodies. Prerequisites: ChEN307 or ChEN308 or MTGN461. 3 hours lecture; 3 semester hours.

MLGN563. POLYMER ENGINEERING: STRUCTURE, PROPERTIES AND PROCESSING. 3.0 Semester Hrs.

(II) An introduction to the structure and properties of polymeric materials, their deformation and failure mechanisms, and the design and fabrication of polymeric end items. The molecular and crystallographic structures of polymers will be developed and related to the elastic, viscoelastic, yield and fracture properties of polymeric solids and reinforced polymer composites. Emphasis will be placed on forming techniques for end item fabrication including: extrusion, injection molding, reaction injection molding, thermoforming, and blow molding. The design of end items will be considered in relation to: materials selection, manufacturing engineering, properties, and applications. Prerequisite: MTGN311 or equivalent. 3 hours lecture; 3 semester hours.

MLGN565. MECHANICAL PROPERTIES OF CERAMICS AND COMPOSITES. 3.0 Semester Hrs.

(II) Mechanical properties of ceramics and ceramic-based composites; brittle fracture of solids; toughening mechanisms in composites; fatigue, high temperature mechanical behavior, including fracture, creep deformation. Prerequisites: MTGN445 or MLGN505. 3 hours lecture; 3 semester hours. (Fall of even years only.).

MLGN569. FUEL CELL SCIENCE AND TECHNOLOGY. 3.0 Semester Hrs.

Equivalent with MTGN569,
(II) Investigate fundamentals of fuel-call operation and electrochemistry from a chemical thermodynamics and materials science perspective. Review types of fuel cells, fuel-processing requirements and approaches, and fuel-cell system integration. Examine current topics in fuel-cell science and technology. Fabricate and test operational fuel cells in the Colorado Fuel Cell Center. Prerequisites: EGGN371 or ChEN357 or MTGN351 Thermodynamics I, MATH225 Differential Equations. 3 credit hours.

MLGN570. BIOCOMPATIBILITY OF MATERIALS. 3.0 Semester Hrs.

(II) Introduction to the diversity of biomaterials and applications through examination of the physiologic environment in conjunction with compositional and structural requirements of tissues and organs. Appropriate domains and applications of metals, ceramics and polymers, including implants, sensors, drug delivery, laboratory automation, and tissue engineering are presented. Prerequisites: ESGN 301 or equivalent. 3 hours lecture; 3 semester hours.

MLGN572. BIOMATERIALS. 3.0 Semester Hrs.

Equivalent with MTGN572,
A broad overview on materials science and engineering principles for biomedical applications with three main topics: 1) The fundamental properties of biomaterials; 2) The fundamental concepts in biology; 3) The interactions between biological systems with exogenous materials. Examples including surface energy and surface modification; protein adsorption; cell adhesion, spreading and migration; biomaterials implantation and acute inflammation; blood-materials interactions and thrombosis; biofilm and biomaterials-related pathological reactions. Basic principles of bio-mimetic materials synthesis and assembly will also be introduced. 3 hours lecture; 3 semester hours.

MLGN583. PRINCIPLES AND APPLICATIONS OF SURFACE ANALYSIS TECHNIQUES. 3.0 Semester Hrs.

(II) Instrumental techniques for the characterization of surfaces of solid materials. Applications of such techniques to polymers, corrosion, metallurgy, adhesion science, micro-electronics. Methods of analysis discussed: X-ray photoelectron spectroscopy (XPS), auger electron spectroscopy (AES), ion scattering spectroscopy (ISS), secondary ion mass spectroscopy (SIMS), Rutherford backscattering (RBS), scanning and transmission electron microscopy (SEM, TEM), energy and wavelength dispersive X-ray analysis; principles of these methods, quantification, instrumentation, sample preparation. Prerequisite: B.S. in metallurgy, chemistry, chemical engineering, physics. 3 hours lecture; 3 semester hours. This course taught in alternate even numbered years.

MLGN591. MATERIALS THERMODYNAMICS. 3.0 Semester Hrs.

A review of the thermodynamic principles of work, energy, entropy, free energy, equilibrium, and phase transformations in single and multi-component systems. Students will apply these principles to a broad range of materials systems of current importance including solid state materials, magnetic and piezoelectric materials, alloys, chemical and electrochemical systems, soft and biological materials and nanomaterials. Prerequisite: 300 level thermodynamics, multivariable calculus and differential equations, introductory college chemistry, and introductory materials science courses or consent of instructor.

MLGN592. ADVANCED MATERIALS KINETICS AND TRANSPORT. 3.0 Semester Hrs.
A broad treatment of homogenous and heterogeneous kinetic transport and reaction processes in the gas, liquid, and solid states, with a specific emphasis on heterogeneous kinetic processes involving gas/solid, liquid/solid, and solid/solid systems. Reaction rate theory, nucleation and growth, and phase transformations will be discussed. A detailed overview of mass, heat, and charge transport in condensed phases is provided including a description of fundamental transport mechanisms, the development of general transport equations, and their application to a number of example systems. Prerequisite: 300 level thermodynamics, multivariable calculus and differential equations, introductory college chemistry, and introductory materials science courses or consent of instructor.

MLGN593. BONDING, STRUCTURE, AND CRYSTALLOGRAPHY. 3.0 Semester Hrs.
This course will be an overview of condensed matter structure from the atomic scale to the mesoscale. Students will gain a perspective on electronic structure as it relates to bonding, long range order as it relates to crystallography and amorphous structures, and extend these ideas to nanostructure and microstructure. Examples relating to each hierarchy of structure will be stressed, especially as they relate to reactivity, mechanical properties, and electronic and optical properties. Prerequisite: 300 level thermodynamics, multivariable calculus and differential equations, introductory college chemistry, and introductory materials science courses or consent of instructor.

MLGN597. CASE STUDY - MATERIALS SCIENCE. 0.5-6 Semester Hr.
Individual research or special problem projects supervised by a faculty member.
Course Learning Outcomes

- Graduates will demonstrate the ability to conduct directed research; the ability to assimilate and assess scholarship; and the ability to apply scholarship in new, creative and productive ways.

MLGN598. SPECIAL TOPICS. 6.0 Semester Hrs.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Prerequisite: none. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

MLGN599. CASE STUDY MATERIALS SCIENCE. 0.5-6 Semester Hr.
(I, II, S) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Variable credit: 0.5 to 6 credit hours. Repeatable for credit under different topics/experience and maximums vary by department. Contact the Department for credit limits toward the degree. Prerequisite: Independent Study form must be completed and submitted to the Registrar.

MLGN607. CONDENSED MATTER. 3.0 Semester Hrs.
(I) Principles and applications of the quantum theory of electronic in solids: structure and symmetry, electron states and excitations in metals; transport properties. Prerequisite: PHGN520 and PHGN440/MLGN502. 3 hours lecture; 3 semester hours.

MLGN698. SPECIAL TOPICS. 6.0 Semester Hrs.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Prerequisite: none. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

MLGN699. INDEPENDENT STUDY. 0.5-6 Semester Hr.
(I, II, S) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit: 0.5 to 6 credit hours. Repeatable for credit under different topics/ experience and maximums vary by department. Contact the Department for credit limits toward the degree.

MLGN707. GRADUATE THESIS / DISSERTATION RESEARCH CREDIT. 1-15 Semester Hr.
(I, II, S) Research credit hours required for completion of a Masters-level thesis or Doctoral dissertation. Research must be carried out under the direct supervision of the student's faculty advisor. Variable class and semester hours. Repeatable for credit.