EN.515 (MATERIALS SCIENCE AND ENGINEERING)

EN.515.601. Structure and Properties of Materials. 3 Credits.
Topics include types of materials, bonding in solids, basic crystallography, crystal structures, tensor properties of materials, diffraction methods, crystal defects, and amorphous materials.

EN.515.602. Thermodynamics and Kinetics of Materials. 3 Credits.
Topics include laws of thermodynamics, equilibrium of single and multiphase systems, chemical thermodynamics, statistical thermodynamics of solid solutions, equilibrium phase diagrams, chemical kinetics, diffusion in solids, nucleation and growth processes, coarsening, and glass transition.

EN.515.603. Materials Characterization. 3 Credits.
This course will describe a variety of techniques used to characterize the structure and composition of engineering materials, including metals, ceramics, polymers, composites, and semiconductors. The emphasis will be on microstructural characterization techniques, including optical and electron microscopy, x-ray diffraction, and acoustic microscopy. Surface analytical techniques, including Auger electron spectroscopy, secondary ion mass spectroscopy, x-ray photoelectron spectroscopy, and Rutherford backscattering spectroscopy. Real-world examples of materials characterization will be presented throughout the course, including characterization of thin films, surfaces, interfaces, and single crystals.

EN.515.604. Electrical, Optical and Magnetic Properties. 3 Credits.
An overview of electrical, optical and magnetic properties arising from the fundamental electronic and atomic structure of materials. Continuum materials properties are developed through examination of microscopic processes. Emphasis will be placed on both fundamental principles and applications in contemporary materials technologies. Course Note(s): Please note that this 515 course is also listed as a 510 course in the full-time program. It is the same course. Part-time students should register for the 515 course.

EN.515.605. Electrical, Optical and Magnetic Properties. 3 Credits.
An overview of electrical, optical and magnetic properties arising from the fundamental electronic and atomic structure of materials. Continuum materials properties are developed through examination of microscopic processes. Emphasis will be placed on both fundamental principles and applications in contemporary materials technologies. Course Note(s): Please note that this 515 course is also listed as a 510 course in the full-time program. It is the same course. Part-time students should register for the 515 course.

EN.515.606. Chemical and Biological Properties of Materials. 3 Credits.
An introduction to the chemical and biological properties of organic and inorganic materials. Topics include an introduction to polymer science, polymer synthesis, chemical synthesis, and modification of inorganic materials, biomineralization, biosynthesis, and properties of natural materials (proteins, DNA, and polysaccharides), structure-property relationships in polymeric materials (synthetic polymers and structural proteins), and materials for biomedical applications. Course Note(s): Please note that this 515 course is also listed as a 510 course in the full-time program. It is the same course. Part-time students should register for the 515 course. Recommended Course Background: undergraduate chemistry and biology or permission of instructor.

EN.515.608. Biomaterials II: Host Response and Biomaterials Applications. 3 Credits.
This course focuses on the interaction of biomaterials with the biological system and applications of biomaterials. Topics include host reactions to biomaterials and their evaluation, cell-biomaterials interaction, biomaterials for tissue engineering applications, biomaterials for controlled drug and gene delivery, biomaterials for cardiovascular applications, biomaterials for orthopedic applications, and biomaterials for artificial organs. Course Note(s): Please note that this 515 course is also listed as a 510 course in the full-time program. It is the same course. Part-time students should register for the 515 course.

EN.515.611. Computational Molecular Dynamics. 3 Credits.
This course aims to enable the student to understand and predict properties of microscopic systems in materials science, physics, biology, and chemistry. We will cover the basics of molecular simulation methods, and provide an overview of modeling tools for problems of interest. In particular this course will cover both hard and soft matter materials spaces. The course is geared toward students with an interest in molecular modeling, with or without prior experience in the area. At the end of this course, students should have a general knowledge of current state-of-the-art molecular simulation methods, and be able to design, run, and analyze simulations for systems of interest.

EN.515.615. Physical Properties of Materials. 3 Credits.
A detailed survey of the relationship between materials properties and underlying microstructure. Structure/property/processing relationships will be examined across a wide spectrum of materials including metals, ceramics, polymers and biomaterials, and properties including electrical, magnetic, optical, thermal, mechanical, chemical and biocompatibility. Course Note(s): Please note that this 515 course is also listed as a 510 course in the full-time program. It is the same course. Part-time students should register for the 515 course.

EN.515.616. Introduction To Nanotechnology. 3 Credits.
Nanoscale science and nanotechnology are broad, interdisciplinary areas, encompassing not just materials science but everything from biochemistry to electrical engineering and more. This will be a survey course introducing some of the fundamental principles behind nanotechnology and nanomaterials, as well as applications of nanotechnology. The role of solid-state physics and chemistry in nanotech will be emphasized. Nanoscale tools such as surface probe and atomic force microscopy, nanolithography, and special topics such as molecular electronics will also be covered.

EN.515.617. Nanomaterials. 3 Credits.
Nanomaterials is a survey course that covers concepts and the associated relevant physics and materials science of what makes nanoscale materials so unique. We’ll learn about nanoscale characterization (electron and probe microscopy), fabrication at the nanoscale (self-assembly and top-down fabrication), and many current applications of nanomaterials across broad areas from medicine to defense. This course will take an in-depth look at nanomaterials discussed in Introduction to Nanotechnology; however, it stands alone with no prerequisite.

EN.515.620. Nanoparticles. 3 Credits.
Nanoparticles - one-dimensional materials with diameters of nearly atomic dimension - are one of the most important classes of nanostructured materials because their unusual properties that often differ significantly from bulk materials. This course will explore the synthesis, structure and properties of nanoparticles. Applications of nanoparticles in medicine, optics, sensing, and catalysis will be discussed, with an emphasis will be on metal nanoparticles and semiconductor quantum dots. Course Note(s): Part-time students should register for the 515 course.

EN.515.621. Biomolecular Materials I: Soluble Proteins & Amphiphiles. 3 Credits.
EN.515.622. Micro and Nano Structured Materials & Devices. 3 Credits.
Almost every material's property changes with scale. We will examine ways to make micro- and nano-structured materials and discuss their mechanical, electrical, and chemical properties. Topics include the physics and chemistry of physical vapor deposition, thin film patterning, and microstructural characterization. Particular attention will be paid to current technologies including computer chips and memory, thin film sensors, diffusion barriers, protective coatings, and microelectromechanical (MEMS) devices. Course Note(s): Part-time students should register for the 515 course.

EN.515.627. Chemistry of Nanomaterials. 3 Credits.
This course introduces the fundamental principles necessary to understand the behavior of materials at length scales larger than atoms or molecules with applications in chemistry and materials science. This course will explore topics such as nanoparticle synthesis and self assembly, ordered porous materials, catalysis, nanostructured thin films, and solar energy conversion. Size dependent properties of nanomaterials will be discussed.

EN.515.628. Introduction to Solid State Chemistry. 3 Credits.
This course focuses on understanding materials properties and their impact on engineering systems. Students in this course will explore the interrelationships among the atomic structure, bonding, and defects, and their influence on the electrical, magnetic, and optical properties of materials. This course will cover topics related to: atomic arrangement; synthesis and processing of materials; characterization using x-ray, thermal and electrochemical methods; specialized topics involving real-world examples drawn from industry including semiconductor processing, energy conversion and storage, and emerging materials-specific technologies.

EN.515.634. Fundamentals of Metamaterials. 3 Credits.
This course introduces the student to the field of metamaterials. The course will begin with a review of basic electromagnetic wave propagation and interaction with matter. The remainder of the course will discuss how metamaterials can be utilized to manipulate electromagnetic fields. Topics will include negative refractive index, perfect lensing, metasurfaces, artificial magnetic conductors, and absorbers.

EN.515.635. Mechanical Properties of Materials. 3 Credits.
This course will consist of a detailed study of the mechanical properties of materials. Topics covered will include stress-strain behavior, elastic and plastic deformation mechanisms, failure mechanisms in quasi-static and dynamic loading conditions, and microstructure-properties relationships. These topics will be discussed as applied to metallic, ceramic, polymeric, and composite materials at bulk and nano scales. The course will also introduce destructive and non-destructive mechanical testing methods. Course Note(s): Please note that this 515 course is also listed as a 510 course in the full-time program. It is the same course. Part-time students should register for the 515 course.

EN.515.636. Chemical Synthesis and Processing of Advanced Materials. 3 Credits.
This is a treatise course on chemical processing of materials. The primary objective of this course is to provide an introduction to various chemical synthesis and formulation techniques for the study of advanced materials including metals, alloys, semiconductors, ceramics, carbons, polymers, coatings, thin films, nanoparticles, and nanostructured materials. The course will discuss both established chemical processing methods and recent advances in materials synthesis and fabrication. Other topics to be covered include thermodynamics and kinetics in chemistry, structure-property relations, and materials characterization techniques.
EN.515.658. Design for Additive Manufacturing. 3 Credits.
This class builds on material covered in the Additive Manufacturing (AM) overview class (515.656) and previous Materials Science and Engineering courses such as Thermodynamics and Kinetics of Materials (515.602). We will learn the design process and design for AM specifically. Students will determine applications and opportunities to apply AM technology and also learn how to evaluate AM designs. Topics will include work flow decisions to determine AM application, design considerations for metal and polymer AM, design for multi-material and functional assembly applications, and AM design evaluation.

EN.515.655 Metal Additive Manufacturing

EN.515.661. Introduction to Polymer Science. 3 Credits.
The goal of this course is to provide students with an introduction to the preparation, properties and manufacturing of polymers. Methods for synthesizing polymers, manufacture of polymers and the techniques used to characterize polymer properties will be presented. The course topics include natural and synthetic giant molecules; inorganic and organic polymers; biomacromolecules; and elastomers, adhesives, coatings, fibers, plastics, blends, caulks, composites, and ceramics. The basic principles that apply to one polymer class can be used to understand all of the other classes and are integrated into the framework of this course.

EN.515.730. Materials Science and Engineering Project. 3 Credits.
This course is an individually tailored, supervised project that offers research experience through work on a special problem related to each student's field of interest. Upon completion of this course, a written essay must be submitted. The faculty advisor will approve the final essay. All other coursework should be completed before this project begins (or at least completed concurrently with this project). Consent of advisor is required.

EN.515.731. Materials Science and Engineering Project. 3 Credits.
This course is an individually tailored, supervised project that offers research experience through work on a special problem related to each student's field of interest. Upon completion of this course, a written essay must be submitted. The faculty advisor will approve the final essay. All other coursework should be completed before this project begins (or at least completed concurrently with this project). Consent of advisor is required.

EN.515.800. Independent Study in Materials Science and Engineering. 3 Credits.
Independent study allows students to take a specialty course on a topic not currently offered within EP but is related to the expertise of a faculty member. Students enrolled in this course are expected to meet with their instructor on a weekly basis and to complete assignments as required including but not restricted to homework, tests and topical essays. Arrangements for this course should be made between the student and the instructor. Final approval is required from the Program Chair. Generally, only one semester of Independent Study will be approved, but a second semester will be granted with justification. All other coursework should be completed before this project begins (or at least completed concurrently with this project). Program Chair approval is required.

EN.515.801. Independent Study in Material Science and Engineering. 3 Credits.
Second semester of independent study. See description for EN.515.800.