

# MATERIAL SCIENCE (MTSC)

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**MTSC 615. Structure of Solids. 3 Credits.**

Crystallography, reciprocal lattices, Bloch waves, band structure, electronic wave functions, phonons, thermal expansion. Superlattice structures, including liquid crystals. Overview of properties of ceramic, amorphous, polymeric, and composite materials.

**Grading status:** Letter grade.

**MTSC 710. Seminar in Materials Science and Engineering. 1 Credit.**

Students will discuss topics concerning contemporary materials science and engineering and will learn skills and knowledge required to be successful graduate students. The seminars will include workshops presented by invited speakers and research presentations by first- and second-year PhD students. Students are expected to read publications and/or assigned materials, be prepared to present their findings, and participate in class discussion. Course previously offered as APPL 710.

**Grading status:** Letter grade.

**MTSC 715. Visualization in the Sciences. 3 Credits.**

Computational visualization applied in the natural sciences. For both computer science and natural science students. Available techniques and their characteristics, based on human perception, using software visualization toolkits. Project course.

**Grading status:** Letter grade

**Same as:** COMP 715, PHYS 715.

**MTSC 720. Materials Fabrication. 3 Credits.**

Permission of the department. Introduction to materials fabrication and characterization techniques. Includes single crystal growth, thin film deposition, synthesis of quantum dots and nanotubes/nanowires, dielectric and electron emissive materials, nanocomposites, bioceramics, and energy storage materials.

**Grading status:** Letter grade.

**MTSC 730. Statistical Thermodynamics. 3 Credits.**

Permission of the instructor. Theory of ensembles and interactions in statistical mechanics. Classical and quantum statistics. Applications to simple systems: ideal gas, heat capacity of solids, blackbody radiation, phase transitions.

**Grading status:** Letter grade.

**MTSC 735. Techniques in Materials Science. 3 Credits.**

Permission of the department. Lecture and laboratory in materials analysis techniques, including microscopy, X-ray diffraction and fluorescence, magnetic resonance, thermal analysis, XPS, channeling and RBS, mechanical properties, optical spectroscopy.

**Repeat rules:** May be repeated for credit.

**Grading status:** Letter grade.

**MTSC 740. Advanced Biomaterials. 3 Credits.**

Medical or dental implants or explants are highlighted from textbooks, scientific literature, and personal accounts.

**Requisites:** Prerequisite, BMME 510; Permission of the instructor for students lacking the prerequisite.

**Grading status:** Letter grade

**Same as:** BMME 740.

**MTSC 745. Chemistry of Biomaterials. 3 Credits.**

Focuses on the chemistry and chemical structure-function relationships of soft synthetic biological materials. Topics include chemistry of proteins, peptides, nucleic acids, polysaccharides and lipids, and their incorporation into biomaterials and biosensors; enzymatic reactions; chemical modification of organic and inorganic surfaces using self-assembled monolayer chemistries, bioconjugation chemistries, synthesis of nanoparticles and their application as sensors, application of biological materials for logic operations, fundamentals of supramolecular chemistry.

**Grading status:** Letter grade.

**MTSC 750. Kinetics, Diffusion, and Phase Transitions of Materials. 3 Credits.**

Reaction kinetics in bulk materials. Mass transport, microstructural transformations, and phase transitions in condensed phases. Atom diffusion in solids. Spinodal decomposition.

**Grading status:** Letter grade.

**MTSC 755. Polymer Processing and Properties. 3 Credits.**

How does one process ultrahigh molecular weight polyethylene into ultra-strong fibers or how would you design a polymer shape-memory actuator? Polymer chemistry is important but equally important is the way how polymers are processed. In this course we will discuss the relationship between polymer chemistry, processing and the final, after processing, properties. We will discuss different processing methods that are currently in use) and which parameters play a role in controlling the final properties.

**Grading status:** Letter grade.

**MTSC 760. Complex Fluids: Theory and Applications. 3 Credits.**

Complex fluids are materials we encounter everyday such as pastes, gels, foams, blood, and tissue, yet ones that cannot be categorized within the traditional three states of matter (solid/gas/liquid). In this course, we introduce the main physical and mathematical concepts of the continuum mechanics of complex fluids and follow with microscopic approaches. The course is designed to focus on both theory and applications with hands-on activities and examples.

**Grading status:** Letter grade.

**MTSC 765. Electronic Materials and Devices - Organic and Inorganic. 3 Credits.**

The course introduces the electronic and optical processes in organic molecules and polymers that govern the behavior of practical organic optoelectronic devices. The course begins with an overview of fundamental science of electronic materials and devices. We then discuss their optoelectronic properties of organic molecules, including topics from photophysics, charge transport and injection. Emphasis will be equally placed on the use of both inorganic and organic electronic materials in organic electronic devices.

**Grading status:** Letter grade.

**MTSC 780. Advanced Materials Science. 3 Credits.**

This course covers the physical fundamentals of material science with an in-depth discussion of structure formation in soft and hard materials and how structure determines material mechanical, electrical, thermal, and optical properties. Topics include amorphous and crystal structures, defects, dislocation theory, thermodynamics and phase diagrams, diffusion, interfaces and microstructures, solidification, and theory of phase transformation. Special emphasis will be on the structure-property relationships of (bio)polymers, (nano)composites, and their structure property relationships.

**Grading status:** Letter grade

**Same as:** BMME 780, CHEM 780, PHYS 780.

**MTSC 785. Introduction to Scientific Computing for Materials. 3 Credits.**

An introduction to scientific computing key concepts and applying these concepts to solve problems, focusing on materials science and engineering. An overview of the mathematics basis of each numerical technique is followed with computer programming during and outside of class to apply those techniques. The course will require a final project to understand application software commonly used in materials science and engineering, including molecular dynamics (MD) software and in continuum modeling software.

**Grading status:** Letter grade.

**MTSC 810. Device Physics and Electronic Properties of Solids. 3 Credits.**

Survey of crystal structure, bandstructure, transport. Overview of FETs, heterostructures, light emission, dissipation, noise, integrated circuits, solar cells, and ceramics. Emphasis on physical sources of device behavior.

**Requisites:** Prerequisites, APPL 470 or PHYS 573, MTSC 615, and 730; permission of the instructor for students lacking the prerequisites.

**Grading status:** Letter grade.

**MTSC 820. Optical Properties of Solids. 3 Credits.**

Reflection, waveguides, nonlinear optics, optical switching, photorefractive, optical storage. Optical coupling to electronic states, device applications, optical computing.

**Requisites:** Prerequisites, APPL 470 or PHYS 573, and PHYS 415; permission of the instructor for students lacking the prerequisites.

**Grading status:** Letter grade.

**MTSC 830. Ion-Solid Interactions. 3 Credits.**

Interatomic potentials, range distribution, radiation damage, annealing, secondary defects, analytical techniques, silicon-based devices, implantation in compound semiconductors, and buried layer synthesis. Ion implantation in metals, ceramics, polymers, and biomaterials.

**Requisites:** Prerequisite, APPL 470 or PHYS 573; permission of the instructor for students lacking the prerequisite.

**Grading status:** Letter grade.

**MTSC 840. New Technologies and Device Architecture. 3 Credits.**

Survey of novel and emerging device technologies. Resonant tunneling transistors, HEMT, opto-electronic devices and optical communication and computation, low-temperature electronic, hybrid superconductor devices.

**Requisites:** Prerequisites, APPL 470 or PHYS 573, MTSC 615, and 730; permission of the instructor for students lacking the prerequisites.

**Grading status:** Letter grade.

**MTSC 871. Solid State Physics. 3 Credits.**

Equivalent experience for students lacking the prerequisite. Topics considered include those of PHYS 573, but at a more advanced level, and in addition a detailed discussion of the interaction of waves (electromagnetic, elastic, and electron waves) with periodic structures, e.g., X-ray diffraction, phonons, band theory of metals and semiconductors.

**Requisites:** Prerequisite, PHYS 421.

**Grading status:** Letter grade

**Same as:** PHYS 871.

**MTSC 872. Solid State Physics II. 3 Credits.**

Topics considered include quantum and thermal fluctuations, and thermodynamics of phase transitions in a broad variety of condensed matter systems, their kinetic theory and hydrodynamics, novel materials (two-dimensional electron gas, graphene, topological insulators and superconductors, Dirac/Weyl/nodal line semimetals), condensed matter applications of modern field-theoretical methods (path integral, renormalization group, holography).

**Requisites:** Prerequisite, PHYS 871.

**Grading status:** Letter grade

**Same as:** PHYS 872.

**MTSC 891. Special Topics in Material Science. 1-3 Credits.**

Permission of the department. Current topics in materials science, including electronic and optical materials, polymers, and biomaterials.

**Repeat rules:** May be repeated for credit; may be repeated in the same term for different topics.

**Grading status:** Letter grade.

**MTSC 892. Special Topics in Material Sciences. 3 Credits.**

Advanced specialty topics in material sciences for graduate students.

**Repeat rules:** May be repeated for credit; may be repeated in the same term for different topics; 12 total credits. 4 total completions.

**Grading status:** Letter grade.

**MTSC 893. Special Topics in Material Sciences. 3 Credits.**

Advanced specialty topics in material sciences for graduate students.

**Repeat rules:** May be repeated for credit; may be repeated in the same term for different topics; 12 total credits. 4 total completions.

**Grading status:** Letter grade.

**MTSC 894. Special Topics in Material Sciences. 3 Credits.**

Advanced specialty topics in material sciences for graduate students.

**Repeat rules:** May be repeated for credit; may be repeated in the same term for different topics; 12 total credits. 4 total completions.

**Grading status:** Letter grade.

**MTSC 895. Special Topics in Material Sciences. 3 Credits.**

Advanced specialty topics in material sciences for graduates students.

**Repeat rules:** May be repeated for credit; may be repeated in the same term for different topics; 12 total credits. 4 total completions.

**Grading status:** Letter grade.

**MTSC 896. Special Topics in Material Sciences. 3 Credits.**

Advanced specialty topics in material sciences for graduates.

**Repeat rules:** May be repeated for credit; may be repeated in the same term for different topics; 12 total credits. 1 total completions.

**Grading status:** Letter grade.

**MTSC 897. Special Topics in Material Sciences. 3 Credits.**

Advanced specialty topics in material sciences for graduate students.

**Repeat rules:** May be repeated for credit; may be repeated in the same term for different topics; 12 total credits. 4 total completions.

**Grading status:** Letter grade.

**MTSC 898. Special Topics in Material Sciences. 3 Credits.**

Advanced specialty topics in material sciences for graduate students.

**Repeat rules:** May be repeated for credit; may be repeated in the same term for different topics; 12 total credits. 4 total completions.

**Grading status:** Letter grade.

**MTSC 899. Special Topics in Material Sciences. 3 Credits.**

Advanced specialty topics in material sciences for graduate students.

**Repeat rules:** May be repeated for credit; may be repeated in the same term for different topics; 12 total credits. 4 total completions.

**Grading status:** Letter grade.

**MTSC 992. Master's (Non-Thesis). 3 Credits.**

**MTSC 993. Master's Research and Thesis. 3 Credits.**

Permission of the department.

**Repeat rules:** May be repeated for credit.

**MTSC 994. Doctoral Research and Dissertation. 3 Credits.**

Permission of the department.

**Repeat rules:** May be repeated for credit.