MATERIALS SCIENCE AND ENGINEERING (M S & E)

M S & E 1 – COOPERATIVE EDUCATION PROGRAM
1 credit.

Work experience which combines classroom theory with practical knowledge of operations to provide students with a background upon which to base a professional career.
Requisites: Sophomore standing
Course Designation: Workplace - Workplace Experience Course
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025
Learning Outcomes: 1. Identify and respond appropriately to real-life engineering ethics cases relevant to co-op work
Audience: Undergraduate

2. Synthesize and apply appropriate technical education to real world technical work
Audience: Undergraduate

3. Communicate effectively in writing and speaking with a range of audiences in the workplace, including those without disciplinary expertise
Audience: Undergraduate

4. Develop professional and transferable habits like time management skills, collaborative problem-solving skills, and research skills for learning new information
Audience: Undergraduate

M S & E 151 – MATERIALS OF THE MODERN WORLD
3 credits.

The properties and structure of everyday materials. A non-mathematical exploration of the relation between structure and resulting properties of metals, plastics, ceramics, glasses, and composite materials. Case studies of important materials in the modern and historical context.
Requisites: None
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Elementary
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Classify types of modern materials and their properties
Audience: Undergraduate

2. Describe the relationship between materials properties and atomic to microscopic scales
Audience: Undergraduate

3. Explore case studies of modern and historic applications
Audience: Undergraduate

4. Explain the role of materials in current and future applications
Audience: Undergraduate

M S & E 250 – INTRODUCTION TO MODERN MATERIALS
1 credit.

This course is designed to provide incoming students with an overview of the structure of materials and the relation to properties. Special emphasis is placed on modern materials and recent advancements in their application.
Requisites: None
Repeatable for Credit: No
Last Taught: Fall 2015

M S & E 260 – MATERIALS EXPERIENCE
2 credits.

Provides overview of the field of Materials Science and Engineering, with significant design and hands-on components. Highlights different types of materials, with a focus on describing the extensive impact that Materials Science and Engineering has had on society. Small teams provide hands-on experience in materials design, synthesis, and processing and the fabrication of materials with desired properties and function.
Requisites: (MATH 113, 114, or 171) and (CHEM 103, 109, or 115 or concurrent enrollment)
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Acquire introductory competency in materials science and engineering principles.
Audience: Undergraduate

2. Describe the broad impact of materials science and engineering on society.
Audience: Undergraduate

3. Learn the basics of materials design, synthesis, processing, properties, and function in a hand-on laboratory setting.
Audience: Undergraduate

4. Develop communication skills including laboratory notebook organization, oral presentation, and technical reporting.
Audience: Undergraduate

5. Obtain professional skills pertaining to team-based problem solving, project management, multicriteria optimization, and engineering ethics.
Audience: Undergraduate

M S & E 299 – INDEPENDENT STUDY
1-3 credits.

Independent study under faculty supervision.
Requisites: Consent of instructor
Repeatable for Credit: No
Last Taught: Spring 2024

M S & E 330 – THERMODYNAMICS OF MATERIALS
4 credits.

Introduction to thermodynamics of materials, equilibrium constants, solutions, heterogeneous equilibria and electrochemistry.
Requisites: MATH 222 and (CHEM 104, 109, or 115), or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Apply the basic principles of the thermodynamics to important processes in materials such as diffusion, phase transformations, and chemical reactions
Audience: Undergraduate

2. Predict the stable chemical and physical state of materials under different thermal, mechanical, and chemical conditions
Audience: Undergraduate

3. Evaluate the mutual conversion between the chemical energy of a material and other forms of energy such as thermal, mechanical, electrical
Audience: Undergraduate

4. Communicate the solutions to technical problems through written assignments and group activities
Audience: Undergraduate

5. Connect materials thermodynamics to societal problems in energy and human health
Audience: Undergraduate

M S & E 331 – TRANSPORT PHENOMENA IN MATERIALS
3 credits.

Basic principles of fluid flow, heat transfer and diffusion are introduced. Examples relevant to design and processing of materials including metals, semiconductors, glasses, polymers, and ceramics are given.
Requisites: M S & E 330 and (MATH 319, 320, 376, or concurrent enrollment), or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Apply mathematics, chemistry, physics, and materials science and engineering principles to quantitatively describe fluid flow, heat transport, mass transport, and their interplay during materials processing and production
Audience: Undergraduate

2. Identify materials transport related problems and formulate plans to solve such problems pertaining to the synthesis, fabrication, and purification of materials
Audience: Undergraduate

3. Analyze transport phenomena and processes using both analytical and computational (finite element) methods
Audience: Undergraduate

4. Develop the mathematical and scientific principles to be able to design materials and the processes needed to produce them to meet desired needs within realistic constraints
Audience: Undergraduate

5. Broadly apply transport principles to understand the impact of materials science and engineering production in a global, economic, environmental, and societal context
Audience: Undergraduate

M S & E 332 – MACROPROCESSING OF MATERIALS
3 credits.

Topics include: ironmaking and steelmaking; production of Cu, Zn, Al and Mg by electrolysis; solidification processing of alloys by ingot casting, continuous casting and directional solidification; growth of bulk single crystals of semiconductors and ceramics from melts.
Requisites: M S & E 350, 351, or CBE 440, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Describe how macroscopic-scale materials are produced from ores, including ironmaking, steelmaking, electrolysis of aluminum, and electrolysis of magnesium
Audience: Undergraduate

2. Describe how macroscopic-scale materials are manufactured, including casting and welding of metals; molding of plastics; preparation of composites; growth of bulk single crystals of semiconductors and oxides; preparation of materials very complicated in shape (additive manufacturing)
Audience: Undergraduate

3. Design the processes for the production of macroscopic-scale materials
Audience: Undergraduate

4. Recognize the impact of the production of macroscopic-scale materials on the environment
Audience: Undergraduate

M S & E 333 – MICROPROCESSING OF MATERIALS
3 credits.

Integration of materials science theory and materials engineering practice as applied to the processing of materials at the microscopic level.
Requisites: M S & E 350, 351, or CBE 440, or member of Engineering Guest Students
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025
Learning Outcomes: 1. Explain basic semiconductor physics, and apply these same physics to approximate device carrier densities, mobility, switching behavior, and other electronically related quantities
Audience: Undergraduate

2. Design process flows based on the physical processes required for desired outcomes in target semiconductor device structures
Audience: Undergraduate

3. Describe how lithography processes are executed and be able to weigh the benefits of each lithography technique against each other
Audience: Undergraduate

4. Analyze device characteristics and connect this analysis with designed process flows
Audience: Undergraduate

M S & E 350 – INTRODUCTION TO MATERIALS SCIENCE
3 credits.

The basic structures and resulting properties of solid materials, including phase equilibria, meta-stability, mechanical properties, failure, corrosion, and materials selection.
Requisites: CHEM 103, 109, 115, graduate/professional standing, or member of Engineering Guest Students. Not open to students with credit in M S & E 351.
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Describe some of the ways a range of materials, including ceramics, metals, and polymers, have economic, societal, and political ramifications, both on the present and in history
Audience: Undergraduate

2. Explain how the structure inside a material can be manipulated across a wide range of length scales (0.1nm – 1mm) to control its properties
Audience: Undergraduate

3. Analyze the interrelationships among structure, processing, properties, and performance in material
Audience: Undergraduate

4. Justify the use of a material based on the material properties, the engineering constraints of project, functionality, and human and environmental interaction
Audience: Undergraduate

5. Demonstrate a quantitative understanding of material properties and structure
Audience: Undergraduate

6. Interpret commonplace representations of data and concepts in materials (e.g. Arrhenius relationship, TTT diagram, Larson-Miller Plot, Ashby Map)
Audience: Undergraduate

7. Communicate with peers to analyze problems in materials selection and design and develop skills for working in collaborative environments
Audience: Undergraduate

M S & E 351 – MATERIALS SCIENCE-STRUCTURE AND PROPERTY RELATIONS IN SOLIDS
3 credits.

Introduction to: atomic, electronic, and defect structures in materials; diffusional, mechanical and electrical properties of materials; and the role of structure and defects in diffusional, mechanical, and electrical properties.
Requisites: MATH 222 and (CHEM 103, 109, or 115), or member of Engineering Guest Students. Students with credit for M S & E 350 may not enroll in M S & E 351.
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Describe atomic-scale structure of crystalline materials and their defects using standard materials science and engineering methods
Audience: Undergraduate

2. List major mechanical and electrical properties of materials and the stimuli and responses they connect
Audience: Undergraduate

3. Describe relationships among elements of materials structure and materials properties at an introductory level and use them to predict materials behavior at an introductory level
Audience: Undergraduate

4. Exhibit skills required for successful completion of the MS&E undergraduate curriculum
Audience: Undergraduate

M S & E 352 – MATERIALS SCIENCE-TRANSFORMATION OF SOLIDS
3 credits.

The basic factors that determine phase equilibria, structural and transformation characteristics of solids. Principles governing the thermodynamics and kinetics of phase transformations and microstructure evolution. Nucleation and growth processes in precipitation, recrystallization, solidification, oxidation, martensitic, ordering and spinodal reactions. Transformation behavior in polymers, biomaterials and nanomaterials.
Requisites: M S & E 350, 351, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Identify the basic factors that determine phase equilibria, structural and transformation characteristics of solids
Audience: Undergraduate

2. Apply principles of thermodynamics and kinetics to phase transformations and microstructure evolution
Audience: Undergraduate

3. Express nucleation and growth processes in precipitation, recrystallization, solidification, oxidation, martensitic, ordering and spinodal reactions
Audience: Undergraduate

4. Extend to transformation behavior in polymers, biomaterials and nanomaterials
Audience: Undergraduate

M S & E 360 – STRUCTURES & PHASES LAB
2 credits.

Laboratory instruction in sample preparation for and applications of quantitative microscopy, x-ray diffraction, and properties measurement in the context of structure-property relationships in materials.
Requisites: M S & E 350 or (M S & E 351 or concurrent enrollment) and declared in Materials Science and Engineering BS or Applied Mathematics, Engineering and Physics BS
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Characterize the structure and properties of materials using imaging and diffraction methods
Audience: Undergraduate

2. Perform experiments to explore the connections among composition, structure, and properties
Audience: Undergraduate

3. Perform data analysis including linear curve fitting and uncertainty analysis
Audience: Undergraduate

4. Produce professional reports including bibliography
Audience: Undergraduate

M S & E 361 – KINETICS & THERMODYNAMICS LAB
2 credits.

Experimental principles of materials science. Thermal, kinetic, structural, and materials synthesis experiments and associated concepts, data analysis, and presentation.
Requisites: Declared in Materials Science and Engineering BS or Applied Mathematics, Physics and Engineering BS and (M S & E 351 and 360)
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Perform experiments measuring structure, properties, kinetics, and thermodynamics
Audience: Undergraduate

2. Explore correlations among structure, processing/synthesis, and properties, and relate these to the underlying thermodynamics and the kinetic processes upon which processing/synthesis relies
Audience: Undergraduate

3. Build upon experimental methods to design new experiments
Audience: Undergraduate

4. Perform data analysis to include, for instance, non-linear curve-fitting, error propagation, assessment of systematic error, and computer simulation of experimental data
Audience: Undergraduate

5. Function effectively in groups to carry out joint projects
Audience: Undergraduate

6. Produce professional reports including discussion of experimental hypotheses, presentation of data, and conclusion
Audience: Undergraduate

M S & E 362 – SYNTHESIS & CHARACTERIZATION LAB
3 credits.

Experiments in the mechanical and electronic properties of matter in bulk and thin films; computer instrument control; and data analysis.
Requisites: M S & E 361
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Perform experiments exploring interrelationships across the full materials tetrahedron: synthesis, structure, properties, and performance
Audience: Undergraduate

2. Employ computers to control experiments and take measurements
Audience: Undergraduate

3. Work effectively in collaborative and inclusive teams to design and carry out experiments that seek optimization of materials performance for engineering applications
Audience: Undergraduate

4. Communicate effectively with a range of audiences using oral presentation, interdepartmental technical memos, and scientific posters
Audience: Undergraduate

M S & E 363 – BASIC MATERIALS CHARACTERIZATION TECHNIQUES
2 credits.

The purpose of this course is to familiarize students with a variety of modern characterization techniques. Three general subject areas are covered: Physical Properties: Thermogravic analysis (TGA); differential scanning calorimetry (DSC); dynamic mechanical analysis (DMA); gel permeation chromatography (GPC). Spectroscopy, optical and x-ray: Ultraviolet/visible (VIS), molecular-infrared/Raman, Rheology; x-ray crystal and powder diffraction. Microscopy: scanning electron microscopy (SEM); SEM and energy dispersive analysis (EDS).
Requisites: Declared in Materials Science and Engineering BS or Applied Mathematics, Physics and Engineering BS and (M S & E 351 and 360)
Repeatable for Credit: No

M S & E 401 – SPECIAL TOPICS IN MATERIALS SCIENCE AND ENGINEERING
1-3 credits.

Special topics of interest to students in materials science and engineering.
Requisites: M S & E 350, 351, or graduate/professional standing
Course Designation: Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025
Learning Outcomes: 1. Identify and describe key theories, concepts, and methods in Materials Science and Engineering
Audience: Undergraduate

2. Apply key theories, concepts, and methods in Materials Science and Engineering, using appropriate tools, processes, and/or software
Audience: Undergraduate

3. Apply, analyze, or evaluate advanced theories, concepts, or methods in Materials Science and Engineering
Audience: Undergraduate

M S & E/CHEM 421 – POLYMERIC MATERIALS
3 credits.

Polymer chemistry and physics terminologies, structure-property relationship, polymer characterization, polymer synthesis, material requirements for optoelectronics including conjugated polymers, thin film transistors, light emitting diodes, non-linear optical materials, holographic data storage and liquid crystal polymers.
Requisites: CHEM 341, 343, or member of Engineering Guest Students
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Classify, identify, and write the structure of different types of common polymers
Audience: Undergraduate

2. Characterize the molecular weights of polymers, their microstructure, and morphology
Audience: Undergraduate

3. Describe the common methods for the synthesis of polymers
Audience: Undergraduate

4. Demonstrate quantitative understanding of the kinetics of polymerization
Audience: Undergraduate

5. Characterize the principle thermal transitions that occur in polymers
Audience: Undergraduate

6. Analyze the interrelationships among structure, properties, processing and applications of polymers
Audience: Undergraduate

M S & E/N E 423 – NUCLEAR ENGINEERING MATERIALS
3 credits.

Fundamentals of fuel and cladding behavior in terms of thermal properties, chemical behavior and radiation damage.
Requisites: M S & E 350 or 351, graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024

M S & E/N E 433 – PRINCIPLES OF CORROSION
3 credits.

Thermodynamics and kinetics of metallic corrosion. The common forms of corrosion and corrosion susceptibility tests. Electrochemical measurement of corrosion rates. Corrosion prevention, economic considerations. High temperature oxidation and sulphidation. Corrosion case histories.
Requisites: M S & E 330, or graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024

M S & E 434 – INTRODUCTION TO THIN-FILM DEPOSITION PROCESSES
3 credits.

Introduction to major thin-film deposition techniques and properties of thin films. Evaporation, plasma assisted processes with emphasis on sputter deposition, chemical vapor deposition ion beams. Film properties and characterization methods, applications.
Requisites: (M S & E 330 and 351), graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025

M S & E 441 – DEFORMATION OF SOLIDS
3 credits.

Elastic and plastic deformation of real solids. Dislocation theory with applications to metals and alloys. Fracture, fatigue, brittle failure and methods for measuring the mechanical properties of materials.
Requisites: M S & E 352 or graduate/professional standing
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Apply elementary mechanics and tensor analysis (including Mohr's Circle) to solve problems involving force, displacement, stress, strain, and Hooke's law
Audience: Undergraduate

2. Apply theories of plasticity and viscoelasticity to solve engineering problems in uniform stress/strain
Audience: Undergraduate

3. Predict the mechanical response of a material (including deformation, failure, and microscopic mechanisms) under an arbitrary state of uniform stress or in the presence of stress concentrations and cracks, and across a wide range of temperatures and time-scale
Audience: Undergraduate

4. Choose materials and microstructures to optimize performance for engineering applications
Audience: Undergraduate

M S & E 448 – CRYSTALLOGRAPHY AND X-RAY DIFFRACTION
3 credits.

Crystal symmetry, projection methods, X-ray studies of structural problems in the solid state.
Requisites: M S & E 350 or 351, graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024

M S & E 451 – INTRODUCTION TO CERAMIC MATERIALS
3 credits.

Primary objectives are to: 1) analyze how atoms and ions combine to form 3D crystals and glasses; 2) examine phase equilibria to understand the driving forces for the formation of particular ceramic phases; 3) introduce and discuss the nature of defects in ceramics; 4) discuss the migration of matter and of charge in ceramics; and 5) discuss properties and processing technologies of ceramics.
Requisites: M S & E 352 and (M S & E 330 or concurrent enrollment), or graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Describe how atoms and ions combine to form 3D crystals and glasses
Audience: Undergraduate

2. Relate phase equilibria to the driving forces for the formation of particular ceramic phases
Audience: Undergraduate

3. Recognize properties of ceramics and identify processing technologies of ceramics
Audience: Undergraduate

4. Analyze the nature of defects in ceramics and the migration of matter and charge in ceramics
Audience: Undergraduate

M S & E 456 – ELECTRONIC, OPTICAL, AND MAGNETIC PROPERTIES OF MATERIALS
3 credits.

Quantitative description of electronic, optical, and magnetic structure-property relationships of materials. Strategies for the development of new materials and introduction to applications of these materials.
Requisites: (M S & E 350 or 351) and (PHYSICS 202, 208, 248, or E C E/PHYSICS 235), graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Predict the electronic, optical, and magnetic properties of a material based on knowledge of the type (chemistry) and arrangement (micro- and macrostructure) of its constituent atoms
Audience: Undergraduate

2. Design materials and device properties by engineering the type and arrangement of atoms
Audience: Undergraduate

3. Analyze experimental transport, optical, and magnetic properties measurements and connect the outcomes of these measurements to electronic band structure
Audience: Undergraduate

M S & E 460 – INTRODUCTION TO COMPUTATIONAL MATERIALS SCIENCE AND ENGINEERING
3 credits.

An introduction to the theoretical and computational tools for computational materials, with hands on homework and laboratories. Topics may include atomistic simulation (e.g., molecular dynamics), mesoscale simulation (e.g,. Phase field method), macroscale simulation (e.g., finite element method), thermodynamic and kinetic modeling (CALPHAD method), informatics (e.g., machine learning), and special topics (e.g., solar cell design, electronic device simulation, etc.)
Requisites: None
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Recall and utilize basic principles of how computers can aid in materials science and engineering.
Audience: Undergraduate

2. Assess and utilize literature and software tools related to computational materials science and engineering.
Audience: Undergraduate

3. Communicate effectively about technical work in oral and written presentation.
Audience: Undergraduate

M S & E 461 – ADVANCED METAL CASTING
3 credits.

Metallurgical and engineering principles applied in the foundry and related industries, primarily for those interested in foundry engineering.
Requisites: M S & E 350 or 352, graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2023

M S & E/M E 462 – WELDING METALLURGY
3 credits.

Metallurgical principles applied to welding; mechanisms of strengthening, phase equilibria, and microstructure of the weld zone. Modern processes including laser and electron beam welding.
Requisites: None
Repeatable for Credit: No
Last Taught: Fall 2023
Learning Outcomes: 1. Identify the specific types of fusion and solid-state processes for welding specific metals/alloys of specific geometries and joints
Audience: Undergraduate

2. Relate principles of heat transfer, fluid flow, mass transfer, chemical reactions, and phase transformations during welding to the development of microstructure, properties, and defects of welds
Audience: Undergraduate

3. Identify the causes and remedies of various defects in welds, such as gas porosity, loss of strength, loss of toughness, cracking, and corrosion
Audience: Undergraduate

4. Identify processes for welding dissimilar materials, such as aluminum alloys to steels, aluminum alloys to copper
Audience: Undergraduate

M S & E 463 – MATERIALS FOR ELEVATED TEMPERATURE SERVICE
3 credits.

The design, properties, processing and selection of high temperature materials for structural applications. The fundamentals of diffusion, phase transformations, dislocation motion and oxidation governing the high temperature mechanical properties and structural performance of metallic and ceramic materials.
Requisites: M S & E 352, graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024

M S & E 465 – FUNDAMENTALS OF HEAT TREATMENT
3 credits.

Principles of phase transformations, heat transfer and mechanical properties as applied to heat treatment practice. The design, modeling and analysis of heat treatment processes.
Requisites: M S & E 352, graduate/professional standing, or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Spring 2025

M S & E 470 – CAPSTONE PROJECT I
1 credit.

Capstone experiences in materials design, selection, and application. Emphasis on creativity and application of fundamental principles of public identification, experimental design, data acquisition and analysis, and presentation of results.
Requisites: Declared in Materials Science and Engineering BS, M S & E 352, and 362 (or concurrent enrollment in M S & E 362)
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Transition from materials science and engineering theory and concepts to real-world applications
Audience: Undergraduate

2. Conduct literature research including industry engineering standards, tools and techniques on a capstone project topic
Audience: Undergraduate

3. Develop a project's statement of work with a timeline of milestones, tasks, dates, and assignments
Audience: Undergraduate

4. Work effectively with a client (project sponsor) in a team environment, while practicing critical thinking, written and oral communication skills, problem solving and design
Audience: Undergraduate

M S & E 471 – CAPSTONE PROJECT II
3 credits.

Capstone experiences in materials design, selection and application for MSE students. Emphasis on creativity and application of fundamental principles in problem identification, experimental design, data acquisition and analysis, and presentation of results.
Requisites: M S & E 470
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Conduct design of experiments (materials selection or failure modes effects analysis), critically analyze and solve a client sponsored capstone project
Audience: Undergraduate

2. Execute a project's statement of work with a timeline of milestones, tasks, dates, and assignments
Audience: Undergraduate

3. Apply industry engineering standards, tools and techniques while conducting design of experiments and research in a capstone project
Audience: Undergraduate

4. Work effectively with a client (project sponsor) in a team environment, while practicing critical thinking, written and oral communication skills, problem solving and design
Audience: Undergraduate

5. Demonstrate skill at project management including navigating the relationships among scheduling, planning, and prioritization of milestones and tasks
Audience: Undergraduate

6. Practice hands-on knowledge in areas that range from experimental design and project management to interpretation and presentation of results
Audience: Undergraduate

7. Apply modern laboratory techniques, skills, and engineering tools appropriate to materials science research and current engineering practices
Audience: Undergraduate

M S & E/CIV ENGR/G L E/GEOSCI 474 – ROCK MECHANICS
3 credits.

Classification of rock masses, stress and strain in rock, linear and non-linear behavior of rock, failure mechanisms, state of stress in rock masses, lab testing, geological and engineering applications.
Requisites: E M A 201, PHYSICS 201, 207, or 247, or graduate/professional standing, or member of Engineering Guest Students
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Measure basic index properties for rock mass classification
Audience: Both Grad & Undergrad

2. Describe stress and strain in continuums
Audience: Both Grad & Undergrad

3. Describe the factors which control the mechanical behavior of rocks
Audience: Both Grad & Undergrad

4. Apply basic concepts of rock mechanics and rock physics to analyze basic geomechanical engineering problems
Audience: Both Grad & Undergrad

5. Prepare rock samples for mechanical testing, conduct experiment, and analyze experimental data to obtain rock strength properties
Audience: Both Grad & Undergrad

6. Describe analytically time-dependent rock behaviors
Audience: Graduate

M S & E 521 – ADVANCED POLYMERIC MATERIALS
3 credits.

This course is directed at graduate and advanced undergraduates with focused interest in polymeric materials. Basic principles of compatibility between macromolecules and small molecules, physical chemistry of blends and concepts in phase separation, and selected topics on materials design using self-assembly concepts.
Requisites: CHEM/M S & E 421, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2024
Learning Outcomes: 1. Analyze and contrast self-assembly across length-scales in natural and synthetic polymers
Audience: Both Grad & Undergrad

2. Relate self-assembled structure and function with the chemistry of the components
Audience: Both Grad & Undergrad

3. Apply the fundamentals of polymer science and concepts of self-assembly, in conjunction with current literature to design functional materials
Audience: Both Grad & Undergrad

4. Analyze problems in materials selection and design
Audience: Both Grad & Undergrad

5. Communicate design concepts to your peers
Audience: Both Grad & Undergrad

6. Demonstrate awareness of the latest advances using the scientific literature, lectures, and independent reading in the field
Audience: Graduate

M S & E 530 – THERMODYNAMICS OF SOLIDS
3 credits.

Thermodynamics of condensed matters as applied to materials science and engineering.
Requisites: M S & E 330, or graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Describe relationships between heat, work, and entropy and its implications for heat engines
Audience: Both Grad & Undergrad

2. Describe the connection between microscopic states and thermodynamic variables and how to calculate the latter from the former using partition functions
Audience: Both Grad & Undergrad

3. Describe how mixing alters the free energy of the unmixed components in terms of ideal and non-ideal contributions
Audience: Both Grad & Undergrad

4. Describe the role of thermodynamic potentials and their implications for materials properties
Audience: Both Grad & Undergrad

5. Describe how Gibbs energy, chemical potential, and activity are related and their role in chemical equilibrium
Audience: Both Grad & Undergrad

6. Read and interpret different types of phase diagrams
Audience: Both Grad & Undergrad

7. Analyze a scientific or engineering problem to obtain selected insights enabled by thermodynamic analysis and communicate them at a basic level
Audience: Undergraduate

8. Analyze a scientific or engineering problem to obtain the major insights enabled by thermodynamic analysis and communicate them at a semi-professional level
Audience: Graduate

M S & E/E M A 541 – HETEROGENEOUS AND MULTIPHASE MATERIALS
3 credits.

Principles of the mechanics of solid multiphase systems. Role of heterogeneity and anisotropy in determining physical properties including elastic, dielectric and piezoelectric properties. Applications in lightweight structures, ultrastrong materials, materials for protection of the body, and materials for the replacement of human tissues. Materials with fibrous, lamellar, particular, and cellular structures. Heterogeneous materials of biological origin. Biomimetic and bio-inspired materials.
Requisites: E M A 303, M E 306, or M S & E 441, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2022

M S & E 550 – MATERIALS FUNDAMENTALS
3 credits.

Accelerated introduction to foundational materials concepts and the materials paradigm approach to problem solving and research. Atomic scale structure of materials; defects in crystalline materials; alloy phase diagrams, solid-state diffusion, phase transformations, microstructure development, micro/nano/atomic-scale structure-property relationships.
Requisites: Graduate/professional standing. Not open to students with credit in M S & E 350, 351, or 352.
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Prepare to succeed in graduate level courses offered by the Materials Science and Engineering department
Audience: Graduate

2. Analyze scholarly publications in their field of research at the level expected of an entry-level researcher
Audience: Graduate

3. Analyze technical challenges in terms of structure-properties-processing-performance relationships
Audience: Graduate

M S & E 551 – STRUCTURE OF MATERIALS
3 credits.

Atomic, nanoscale and microscale structure of materials. Course is designed for first year graduate students with interests in materials research.
Requisites: M S & E 451, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Describe the atomic-scale structure of materials using multiple methods including one or more not typically required for B.S. degree in materials science and engineering
Audience: Both Grad & Undergrad

2. Articulate the role of crystal symmetry in expression and anisotropy of properties at a level not typically required for a B.S. degree in materials science and engineering
Audience: Both Grad & Undergrad

3. Describe the characteristics of crystal defects at a more advanced level than typically required for a B.S. degree in materials science and engineering
Audience: Both Grad & Undergrad

4. Complete the structures section of the qualifying exam successfully if enrolled in the Ph.D. program
Audience: Graduate

M S & E 553 – NANOMATERIALS & NANOTECHNOLOGY
3 credits.

The principal objectives of the course are to: i) introduce advanced processing methods for synthesizing nanomaterials, ranging from single nanoparticles to three-dimensional nanostructures, ii) discuss important thermodynamic and kinetic theories related to such processing, iii) describe methods for characterizing the structure and properties of nanomaterials, iv) discuss current and emerging applications for nanomaterials, and v) illustrate the interdisciplinary nature of nanotechnology and address critical challenges.
Requisites: M S & E 350, 351, or CBE 440, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Comprehend the scope and advances of nanomaterials and nanotechnology
Audience: Both Grad & Undergrad

2. Explain the fundamental physical and chemical knowledges involved in nanoscience
Audience: Both Grad & Undergrad

3. Relate the physical and chemical property of nanomaterials with their performance in different applications
Audience: Both Grad & Undergrad

4. Analyze the synthesis and fabrication of nanomaterials and their devices
Audience: Both Grad & Undergrad

5. Propose research projects that involve the use of nanomaterials/ nanotechnology for certain applications
Audience: Graduate

6. Evaluate a research proposal from fundamental nanomaterials point of view
Audience: Undergraduate

M S & E 560 – FUNDAMENTALS OF ATOMISTIC MODELING
3 credits.

Introduction to basic concepts of atomistic modeling in materials, including classical and quantum mechanical energy methods, energy optimization, molecular statistics, molecular dynamics, and Monte Carlo. Relevant aspects of thermodynamics, statistical mechanics, quantum mechanics, and computer programming will also be presented.
Requisites: None
Repeatable for Credit: No
Last Taught: Spring 2017

M S & E 561 – MACHINE LEARNING IN MATERIALS
3 credits.

Introduction to applications of data science in materials science and engineering, including understanding the creation and use of modern data resources, data-centric approaches to materials, and the integration of machine learning across the materials landscape.
Requisites: Satisfied Quantitative Reasoning (QR) B requirement, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Learning Outcomes: 1. Recall and utilize basic principles and methods of how informatics (data science and machine learning) can be used in materials science and engineering
Audience: Both Grad & Undergrad

2. Apply software tools related to materials informatics
Audience: Both Grad & Undergrad

3. Communicate effectively about technical work in oral and written presentation
Audience: Both Grad & Undergrad

4. Develop machine learning workflows for informatics applications in materials science and engineering
Audience: Graduate

M S & E 570 – PROPERTIES OF SOLID SURFACES
3 credits.

Introduction to structure and electronic properties; surface energy; thermodynamics of surfaces; diffusion. Surface barriers, work function, vibrational and electronic states. Chemical interactions: chemisorption, oxidation, corrosion, absorption kinetics, catalysis. Experimental methods and applications in metals, semiconductors.
Requisites: PHYSICS 205, 241, 244, or (M S & E 351 and 333) or PHYSICS/E C E 235, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Explain how and why the surface and electronic properties of solid surfaces and interfaces differ from the bulk
Audience: Both Grad & Undergrad

2. Design and interpret experiments to measure surface properties
Audience: Both Grad & Undergrad

3. Evaluate the efficiency of various experimental techniques in measuring surface composition, surface structure, and electronic properties
Audience: Both Grad & Undergrad

4. Implement surface/interface phenomena in the design of devices
Audience: Graduate

M S & E 648 – ADVANCED X-RAY SCATTERING METHODS IN MATERIALS SCIENCE AND ENGINEERING
3 credits.

Advanced concepts and methods for the use of x-ray scattering, diffraction, and spectroscopy in materials science and engineering. Underpinning fundamental mathematical and scattering concepts, including kinematic and dynamical diffraction, diffuse scattering, and optical coherence in x-ray scattering. Practical aspects of experiments at synchrotron light sources and free electron lasers. Applications, including structure of metals and ceramics, polymeric materials, thin films and nanostructures, and magnetic materials.
Requisites: M S & E 448, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Demonstrate knowledge and understanding of the principles of x-ray scattering, spectroscopy, and diffraction
Audience: Both Grad & Undergrad

2. Apply quantitative x-ray analysis methods to characterization of important materials systems
Audience: Both Grad & Undergrad

3. Communicate the solutions to technical and scientific problems
Audience: Both Grad & Undergrad

4. Connect x-ray scattering to societal problems in energy and human health
Audience: Both Grad & Undergrad

5. Articulate the role of advanced x-ray characterization methods in materials research
Audience: Undergraduate

6. Apply x-ray scattering methods to specific problems in their own graduate-level scientific research
Audience: Graduate

M S & E 660 – MESOSCALE MODELING OF MATERIALS
3 credits.

Classical theories, analytical and numerical modeling of various kinetic processes in materials. Including but not limited to transport, grain growth, phase separation, solidification, precipitation, chemical reactions, and multiphysics problems involving electrical, optical, mechanical, and magnetic properties of materials.
Requisites: (MATH 319, 320, or 376) and (M S & E 350, 351, or CBE 440), graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Apply the theory of irreversible dynamics to analyze many important kinetic processes of materials such as transport, phase transitions, and chemical reactions
Audience: Both Grad & Undergrad

2. Computationally model exemplary mesoscale problems in materials research
Audience: Both Grad & Undergrad

3. Analyze results from a computational model and extract useful understanding from it
Audience: Both Grad & Undergrad

4. Solve several representative types of partial differential equations using both analytical methods and numerical algorithms
Audience: Both Grad & Undergrad

5. Apply these analytical methods and numerical algorithms to students' own research
Audience: Graduate

M S & E 699 – INDEPENDENT STUDY
1-4 credits.

Courses in Metallurgical Engineering.
Requisites: Consent of instructor
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

M S & E 702 – GRADUATE COOPERATIVE EDUCATION PROGRAM
1-2 credits.

Work experience that combines classroom theory with practical knowledge of operations to provide students with a background on which to develop and enhance a professional career. The work experience is tailored for MS students from within the U.S. as well as eligible international students.
Requisites: Consent of instructor
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Summer 2024
Learning Outcomes: 1. Identify and respond appropriately to real-life engineering ethics cases relevant to co-op work
Audience: Graduate

2. Synthesize and apply appropriate technical education to real world technical work
Audience: Graduate

3. Communicate effectively in writing and speaking with a range of audiences in the workplace, including those without disciplinary expertise
Audience: Graduate

4. Develop professional and transferable habits like time management skills, collaborative problem-solving skills, and research skills for learning new information
Audience: Graduate

M S & E 748 – STRUCTURAL ANALYSIS OF MATERIALS
3 credits.

Introduction to transmission electron microscopy of materials, including imaging, diffraction, and microanalysis. Knowledge of diffraction [such as M S & E 448] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2023
Learning Outcomes: 1. Use ray optics and Fourier optics to explain the operating modes and major subsystems of a transmission electron microscope (TEM)
Audience: Graduate

2. Apply electron diffraction theory and electron scattering theory to predict or simulate the results of the interaction of a high energy electron beam with a material, depending on the material's crystal structure, microstructure, composition, and bonding
Audience: Graduate

3. Predict the outcome of TEM experiments including imaging, diffraction, and spectroscopy, given appropriate data about the material's composition, crystal structure, microstructure, and interatomic bonding and information about the TEM experimental conditions
Audience: Graduate

4. Analyze experimental TEM data, including images, diffraction patterns, and spectra, to determine the material's crystal structure, microstructure, composition, or bonding, and the TEM experimental conditions, as appropriate
Audience: Graduate

5. Identify common artifacts in TEM data including images, diffraction patterns, and spectra and explain their origins
Audience: Graduate

6. Design a TEM experimental plan to address a research problem in structure of materials
Audience: Graduate

M S & E 750 – IMPERFECTIONS AND MECHANICAL PROPERTIES
3 credits.

Mathematical theory of dislocations and other crystal imperfections; mechanical properties of crystals in relation to imperfections. Knowledge of crystal structure and dislocations [such as M S & E 551] required.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2024
Learning Outcomes: 1. Apply mechanics and tensor analysis to solve problems in non-uniform strain related to stress-defect and defect-defect interactions
Audience: Graduate

2. Apply theories of plasticity and viscoelasticity to solve 3 dimensional problems in stress and strain
Audience: Graduate

3. Construct models of the strength of materials based on underlying microscopic mechanisms
Audience: Graduate

4. Construct maps of mechanical response (deformation, failure, and microscopic mechanisms) under arbitrary state of stress and in the presence of stress concentrations, cracks, and across a wide range of temperatures, time-scale, and length-scale
Audience: Graduate

M S & E 752 – ADVANCED MATERIALS SCIENCE: PHASE TRANSFORMATIONS
3 credits.

Phase transformations, nucleation theory and the role of structural imperfections, alloy phase equilibria, interface reactions and growth kinetics, continuous transformations. Knowledge of diffusion and reactions [such as M S & E 352] required.
Requisites: (M S & E 530 or concurrent enrollment) and graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

M S & E 756 – STRUCTURE AND PROPERTIES OF ADVANCED ELECTRONIC MATERIALS
3 credits.

Prepares graduate students for research in electronic materials and related areas by examining (1) how does the physical structure of a material affect its electronic structure and properties: and (2) state-of-the-art advance electronic materials. Topics include: molecular and organic semiconductors; carbon nanomaterials (nanotubes, nanoribbons and graphene); advances in conventional bulk zinc-blende and wurtzite semiconductors; polycrystalline, amorphous, and disordered materials; state-of-the-art high- low-k dielectrics; and up-and-coming and next-generation materials. Knowledge of solid state physics [such as PHYSICS 551 or M S & E 456] required.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2023
Learning Outcomes: 1. Examine the physical and electronic structure relationships of advanced electronic materials
Audience: Graduate

2. Analytically deduce how the physical structure and composition of a material affect its electronic structure and properties employing concepts pertaining to quantum mechanics, bonding, crystal structure, spin, symmetry, and dimensionality
Audience: Graduate

3. Utilize concepts and tools including: experimental measurements, scientific literature, and models/calculations of energy and band structure, dielectric spectra, and transport phenomena
Audience: Graduate

4. Analyze conventional bulk zinc-blende and wurtzite semiconductors; oxides; Heuslers; carbon and 2D nanomaterials; polycrystalline and disordered materials; organic semiconducting molecules and crystals; and up-and-coming and next-generation electronic materials
Audience: Graduate

5. Connect fundamental principles to motivations from device applications (field effect transistors; light emitting devices; and photovoltaics)
Audience: Graduate

M S & E 758 – TRANSMISSION ELECTRON MICROSCOPY LABORATORY
1 credit.

An introduction to the practice of transmission electron microscopy (TEM) and TEM sample preparation through hands-on laboratory training.
Requisites: M S & E 748 or concurrent enrollment
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Operate a transmission electron microscope safely for the operator and the instrument
Audience: Graduate

2. Obtain publication quality experimental TEM imaging and diffraction data
Audience: Graduate

3. Obtain publication quality experimental TEM data in one or more additional modalities related to the student's research interests
Audience: Graduate

M S & E 760 – MOLECULAR MODELING OF MATERIALS
3 credits.

Hands-on experience in modern tools of atomic and molecular modeling, including density functional theory, interatomic potentials, and molecular dynamics. Select additional/advanced techniques like high-throughput calculations, (Kinetic) Monte Carlo, accelerated molecular dynamics, and machine learning.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Choose and use the appropriate molecular simulations to obtain properties of materials
Audience: Graduate

2. Apply ab initio methods to model materials properties
Audience: Graduate

3. Apply molecular dynamics methods to model materials properties
Audience: Graduate

4. Use results of molecular simulations in scientific literature to obtain properties of materials
Audience: Graduate

5. Use molecular simulations to analyze scientific or engineering problems to obtain selected insights and communicate them at a semi-professional level
Audience: Graduate

M S & E 790 – MASTER'S RESEARCH OR THESIS
1-9 credits.

Under faculty supervision.
Requisites: Declared in Materials Science and Engineering M.S., Ph.D., or doctoral minor
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025
Learning Outcomes: 1. Demonstrate an ability to formulate and analyze advanced materials science and engineering problems
Audience: Graduate

2. Communicate research results in writing and seminars
Audience: Graduate

3. Work independently and collaboratively, as appropriate, on solutions for materials science and engineering problems
Audience: Graduate

4. Prepare for academic requirements such as the masters thesis document, masters thesis defense, or graduate preliminary exam
Audience: Graduate

M S & E 803 – SPECIAL TOPICS IN MATERIALS SCIENCE
1-3 credits.

Topics vary.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025
Learning Outcomes: 1. Identify and describe key theories, concepts, and methods in materials science and engineering
Audience: Graduate

2. Apply key theories, concepts, and methods in materials science and engineering, using appropriate tools, equipment, processes, and/or software
Audience: Graduate

3. Apply, analyze, or evaluate advanced theories, concepts, or methods in materials science and engineering
Audience: Graduate

4. Communicate results in writing, in live presentations, written assignments, or recorded presentations
Audience: Graduate

M S & E 890 – PRE-DISSERTATOR'S RESEARCH
1-9 credits.

Under faculty supervision.
Requisites: Declared in Materials Science and Engineering Ph.D. or doctoral minor.
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025
Learning Outcomes: 1. Demonstrate an ability to formulate and analyze advanced materials science and engineering problems
Audience: Graduate

2. Communicate research results in writing and seminars
Audience: Graduate

3. Work independently and collaboratively, as appropriate, on solutions for materials science and engineering problems
Audience: Graduate

4. Prepare for academic requirements such as the graduate preliminary exam
Audience: Graduate

M S & E 900 – MATERIALS RESEARCH SEMINAR
1 credit.

Introduces graduate students to the breadth, wealth and practices of materials research at the University of Wisconsin and in the professional materials research community.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025
Learning Outcomes: 1. Demonstrate awareness of current advances in materials science and engineering research gained from the material science and engineering seminar series
Audience: Graduate

2. Demonstrate awareness of professional responsibilities in maintaining and equitable and inclusive work environment
Audience: Graduate

3. Develop and apply professional skills in technical presentation and writing
Audience: Graduate

4. Demonstrate awareness of professional responsibilities with respect to ethics, intellectual property, and/or appropriate documentation of research
Audience: Graduate

M S & E 990 – RESEARCH AND THESIS
1-9 credits.

Under faculty supervision.
Requisites: Declared in Materials Science and Engineering Ph.D. or doctoral minor.
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025
Learning Outcomes: 1. Demonstrate an ability to formulate and analyze advanced materials science and engineering problems
Audience: Graduate

2. Communicate research results in writing and seminars
Audience: Graduate

3. Work independently and collaboratively, as appropriate, on solutions for materials science and engineering problems
Audience: Graduate

4. Prepare for academic requirements such as the PhD thesis defense and PhD thesis
Audience: Graduate

M S & E 999 – INDEPENDENT WORK
1-3 credits.

Independent study under faculty supervision.
Requisites: Consent of instructor
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2000
Learning Outcomes: 1. Conduct and report on independent materials science and engineering research
Audience: Graduate

2. Independently develop materials science and engineering research directions
Audience: Graduate

3. Appropriately utilize research materials including the scientific and technical literature
Audience: Graduate

4. Connect their research clearly to other research in their field of study
Audience: Graduate