MATERIALS SCIENCE & ENGINEERING (MSE)

MSE 1140 - Materials: The Future of Energy (3 Credits)
Crosslisted with ENGRI 1140
New technologies are urgently needed to fulfill projected global energy requirements. Materials properties typically limit the performance that can be achieved in generation, transport, and utilization of energy. This course will explore how new materials can increase our energy supply, facilitate transportation of energy, and decrease consumption. Materials issues in photovoltaic, fuel cell, battery, transportation, lighting, and building technologies will be studied.
Prerequisites: knowledge of Calculus, Physics, and Chemistry at the high school level.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 1190 - Biomaterials for the Skeletal System (3 Credits)
Crosslisted with ENGRI 1190
Biomaterials exist at the intersection of biology and engineering. This course explores natural structural materials in the human body, their properties and microstructure, and their synthetic and semi-synthetic replacements. Bones, joints, teeth, tendons, and ligaments are used as examples, with their metal, plastic, and ceramic replacements. Topics covered include mechanical properties, corrosion, toxicity, and biocompatibility. Case studies of design lead to consideration of regulatory approval requirements and legal liability issues.
Exploratory Studies: (CU-CEL)

Last Four Terms Offered: Fall 2024, Fall 2023, Spring 2022, Fall 2020
Schedule of Classes (https://classes.cornell.edu/)

MSE 1700 - FWS: Scientific Breakthroughs: Reality or Hyperbole (3 Credits)
Scientists excitedly announce their latest result-it's a breakthrough!- and science journalists and others proclaim that the breakthrough will revolutionize our lives. But is it so? Or are they speculating, exaggerating, or complicit in fraud? Some scientific breakthroughs do change our lives (CRISPR-Cas9) while others fade away ignominiously (Theranos). Case studies will help us develop a critical eye: we will read red-hot announcements along with dispassionate retrospectives, identifying the signs that distinguish flimsy or inflated claims from solid and credible statements. To detect hype, we need only common sense and logical reasoning, not specific or deep scientific expertise. Using carefully constructed and richly argued essays, along with dialogues and speeches, we will interpret and assess the claims of some prominent examples of trumpeted breakthroughs.
Last Four Terms Offered: Fall 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MSE 2060 - Atomic and Molecular Structure of Matter (3 Credits)
Crosslisted with MAE 3130
This course covers the atomic and molecular structure of crystalline and noncrystalline materials as well as selected analytical techniques for structural interrogation. Selected topics include, basic elements of structure; order and disorder; crystals; semicrystalline materials; amorphous materials; molecular materials; x-ray diffraction; small angle x-ray scattering.
Prerequisites: Recommended prerequisite: MSE 2610.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MSE 2610 - Mechanical Properties of Materials: From Nanodevices to Superstructures (4 Credits)
Crosslisted with ENGRD 2610
Examines the mechanical properties of materials (e.g., strength, stiffness, toughness, ductility) and their physical origins. Explores the relationship of the elastic, plastic, and fracture behavior to microscopic structure in metals, ceramics, polymers, and composite materials. Discusses effects of time and temperature on materials properties. Emphasizes considerations for design and optimal performance of materials and engineered objects.
Prerequisites: PHYS 1112 or PHYS 1117.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 2620 - Electronic Materials for the Information Age (3 Credits)
Crosslisted with ENGRD 2620
Examines the electrical and optical properties of materials.
Topics include the mechanism of electrical conduction in metals, semiconductors and insulators; tuning of electrical properties in semiconductors, charge transport across metal/semiconductor and semiconductor/semiconductor junctions, and the interaction of materials with light; semiconductor electronic devices; and the materials science of device fabrication. Applications in microelectronics, solar cells, electronics, and display technologies are discussed. Semiweekly labs provide hands-on experience characterizing electronic materials and devices.
Corequisites: or prerequisite: MATH 2930 and PHYS 2213.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MSE 3010 - Materials Chemistry (3 Credits)
Provides a molecular understanding of materials properties: introductory quantum chemistry, physical organic chemistry, crystal/ligand field theory, sol-gel chemistry, electrochemistry, and corrosion. Materials addressed include polymers, biopolymers, organic semiconductors, photoresists, silicate glasses, optical materials, and silica nanoparticles.
Prerequisites: CHEM 2090 and ENGRD 2620/MSE 2620.
Corequisites: MATH 2930.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 3030 - Thermodynamics of Condensed Systems (4 Credits)
Introduces the three laws of thermodynamics as the fundamental basis for thermal and chemical equilibrium, coupled with statistical mechanical interpretations for entropy. Applies these principles to understand the equilibrium behavior of matter, with a focus on condensed liquid and solid phases. Develops concepts of phase equilibria, phase diagrams, chemical reactions, solution behavior and electrochemistry. Includes an introduction to statistical mechanics and applications in ideal gas behavior, gas and crystal heat capacity, and electron Fermi-Dirac statistics. Applications and examples will be drawn from a range of sub-disciplines spanning metallurgy to polymers.
Prerequisites: MATH 1920 and PHYS 1112.
Corequisites: or prerequisite: MSE 2610 or MSE 2620.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 3040 - Kinetics, Diffusion, and Phase Transformations (3 Credits)
Phenomenological and atomistic theories of diffusion in metals, alloys, ionic compounds, semiconductors and polymers. Introduction to general transport theory and non-equilibrium thermodynamics. Kinetic effects in solidification and solid state transformations that determine structure and properties of materials including: interfaces and microstructure; nucleation, growth and coarsening; alloy solidification; and diffusional and diffusionless transformations in solids.
Prerequisites: MATH 2930 and MSE 3030.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MSE 3050 - Electronic, Magnetic, and Dielectric Properties of Materials (4 Credits)
Examines the electronic, magnetic, and dielectric properties of materials, including an understanding of the atomic level interactions that give rise to these properties. Topics include: use of tensors to describe equilibrium and transport macroscopic physical properties; connection between symmetry and properties; ferroelectrics, ferromagnets, and multiferroics; dispersion relations of phonons and electrons in solids; and effects of defects. Applications in microelectronics are discussed.
Prerequisites: MSE 2060, MSE 2620, MATH 2930, MATH 2940.
Last Four Terms Offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 3070 - Materials Design Concepts I (2 Credits)
Introduces design in the context of real-world materials challenges as explored through reverse engineering. Students examine the materials, design, and cost constraints of a variety of technological products and the solutions commercially implemented. Analytical methods for materials testing and characterization are also introduced as part of the evaluation process. Students work in groups to develop a research plan, characterize materials, and report results. Exercises to develop technical writing and oral presentation skills are integrated throughout the course.
Prerequisites: ENGRD 2610/MSE 2610 or ENGRD 2620/MSE 2620, and MSE 3110.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MSE 3110 - Junior Laboratory I (2 Credits)
Practical laboratory covering the characterization of materials, analysis of data, and presentation of results. Labs are based on concepts from the chemistry of materials (MSE 3010) and thermodynamics of condensed systems (MSE 3030) courses. Experiments include calorimetry, spectroscopic characterization, nanoparticle growth, polymer OLED devices, and molecular origins of spectral data features. Comprehensive data analysis including statistical data analysis, curve fitting and experimental uncertainty is emphasized. Includes an introduction to formal technical writing.
Prerequisites: ENGRD 2610/MSE 2610 or ENGRD 2620/MSE 2620.
Corequisites: or prerequisite: MSE 3010 and MSE 3030.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 3120 - Junior Laboratory II (2 Credits)
Practical laboratory covering the characterization of material, analysis of data, and proper presentation of results. Labs are based on materials from courses in kinetics, diffusion and phase transformations (MSE 3040) and electronic, magnetic and dielectric properties (MSE 3050). Experiments include spectroscopic determination of a diffusion constants, thin film growth kinetics, anisotropic resistivity in polycrystalline materials, and characterization of magnetic properties. Data analysis is extended to include experimental design, use of custom model equations, and precision measurement techniques. Includes also continued development of technical writing skills.
Prerequisites: MSE 3110.
Corequisites: or prerequisite: MSE 3040.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MSE 4020 - Mechanical Properties of Materials, Processing, and Design (3 Credits)
Crosslisted with MAE 3120
Relationship between microscopic mechanisms and macroscopic mechanical behavior of engineering materials, how mechanical properties can be modified, and criteria for selection and use of materials in design. Stress, strain and elastic constants as tensor quantities, viscoelasticity and damping, plastic deformation, creep deformation, fracture, and fatigue.
Prerequisites: MAE 3270 or MSE 2610.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 4030 - Senior Materials Laboratory I (4 Credits)
Experiential learning course in which students participate in eitber a faculty or industry led, semester-long, team research project. Teams of three or four students research a topic, define research questions, design and conduct original research to answer the questions, and analyze their data. Group presentations and a final journal style paper required. In addition to developing research skills, students practice and develop communication/team skills, presentation skills, and technical writing skills.
Prerequisites: MSE 3070 and MSE 3120.
Enrollment Information: Enrollment limited to: seniors in MSE.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 4050 - Senior Experimental Thesis I (3 Credits)
First semester of a two-semester thesis course involving research in faculty laboratories. Students work alongside faculty, postdocs, and graduate students to conduct original materials research over both semesters, and present the results in conference-style talks, a poster, a written thesis, and a research paper. Lectures and discussion groups explore aspects of effective research including defining problems, proposal writing, searching and using the existing research literature, communicating technical results in progress reports, talks, posters and papers. Completion of both 4050 and 4060 is required to satisfy the senior laboratory requirement for graduation, and is required for graduation with honors.
Prerequisites: MSE 3120.
Enrollment Information: Enrollment limited to: advanced undergraduates in lieu of senior materials laboratory.
Exploratory Studies: (CU-UG)

Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 4060 - Senior Experimental Thesis II (3 Credits)
Second semester of two-semester senior thesis sequence. See MSE 4050 for thesis project requirements. Continued research in individual faculty groups with periodic oral and written updates. In class discussion of communication strategies and development of presentation skills. Final thesis will be presented in a formal conference style with (i) oral presentation, (ii) poster session and (iii) conference manuscript. Completion of both 4050 and 4060 required to satisfy senior laboratory requirement for graduation, and is required for graduation with honors.
Prerequisites: MSE 4050.
Enrollment Information: Enrollment limited to: advanced undergraduates in lieu of senior materials laboratory.
Exploratory Studies: (CU-UG)

Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MSE 4070 - Materials Design Concepts II (3 Credits)
This course emphasizes entrepreneurial driven materials enabled designed through the understanding of early stage product development complexities. These complexities include staging invention and innovation via the critical selection of materials for final product function, performance, reliability, cost, and technical marketability. Students will expand on their foundational materials design understanding (MSE 3070 prerequisite) through attending lectures, participating in a team based hands on design startups, attend startup design reviews, give a series of individual/group presentations, and wrtie a startup issue paper. The Tech Startup is integrated into the SC Johnson College of Business (SCJCoB) MBA candidate-mentoring program.
Prerequisites: MSE 3070 and MSE 4071.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MSE 4071 - Materials Design Concepts Transition (0.5 Credits)
Transition course between the initial design course MSE 3070 and the capstone design course MSE 4070. Students develop a proposal to prototype a product design concept after an investigation of available resources and a quantitative feasibility analysis. The students write a brief summarizing the business value proposition of the product in the context of a startup; this brief is used to identify MBA students as mentors for the 4070 teams.
Prerequisites: MSE 3070.
Last Four Terms Offered: Fall 2024
Schedule of Classes (https://classes.cornell.edu/)

MSE 4510 - Materials Processing and Manufacturing (3 Credits)
Crosslisted with MAE 4240
How a material is made into its final form has great importance to its structure and therefore to its properties and performance. This course is aimed at giving students an understanding of the state-of-the-art material processing and manufacturing technologies as well as how these processes influence materials' microstructure and properties. With a unified approach this course will introduce the fundamentals of materials processing applied to metals, ceramics, and polymers. Different material processing routes from melt-based and powder-based processes to shape forming, joining, surface engineering and additive manufacturing will be discussed. Emphasis will be placed on the physics of the process as well as on how the processes will influence the properties of emerging materials and applications.
Prerequisites: ENGRD 2020 or ENGRD 2610.
Enrollment Information: Enrollment limited to: junior and senior students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Describe the physics of materials processes and manufacturing technologies.
- Identify and explain process-microstructure-property relationships for different materials processes.
- Design processing routes and justify process selection for a desired performance.

Schedule of Classes (https://classes.cornell.edu/)

MSE 4610 - Biomedical Materials and Their Applications (3 Credits)
Many types of materials are used in biomedical engineering to replace or supplement natural biological systems. Interaction with blood and tissues is always of primary importance, but depending on the use of the biomedical material, mechanical, optical, and transport properties may also be vital. The first half of the class will focus on establishing a common vocabulary and knowledge base in materials, biochemistry, cell biology, and immunology. The second half of the class will focus on a survey of commercially available biomaterials as well as future prospects.
Corequisites: or prerequisite: CHEM 1570 or CHEM 3570.
Exploratory Studies: (CU-CEL)

Last Four Terms Offered: Fall 2022, Spring 2021, Spring 2020, Spring 2019
Schedule of Classes (https://classes.cornell.edu/)

MSE 4900 - Special Projects in Materials Science and Engineering (1-3 Credits)
Students engage in a mentored investigation or inquiry that aims to make a scholarly contribution to the field of Materials Science and Engineering. Students are mentored by Cornell faculty in the Department of Materials Science and Engineering, and may have additional mentors. Each credit hour requires, on average, 3 hours per week throughout the semester. To enroll, students should schedule a meeting with their mentor(s) to discuss the semester goals, requirements, and expectations associated with the research credit(s). Students must submit a Cornell Engineering Research for Credit Form (https://experience.cornell.edu/opportunities/cornell-engineering-research-credit). Upon approval, students are responsible for enrolling themselves with a permission number.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MSE 4901 - Special Projects for Summer Research Students (2-6 Credits)
Last Four Terms Offered: Summer 2024, Summer 2023, Summer 2022
Schedule of Classes (https://classes.cornell.edu/)

MSE 4950 - Undergraduate Teaching Involvement (1-3 Credits)
Gives credit to students who help in the laboratory portions of select MSE courses. The number of credits earned is determined by the teaching load and is typically 1-3.
Exploratory Studies: (CU-UG)

Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MSE 5005 - MSE MEng Professional Development (1 Credit)
Development of leadership skills and application to problem solving, forming and working on teams, project management, and networking. Development of graphical, verbal, and written communication skills. Effective technical project presentations. Professional portfolio development and marketing. Interpersonal skills and effective group behavior. Corporate, academic, and other cultures. Ethics in professional practice. Personal goal setting and progress metrics.
Enrollment Information: Enrollment limited to: MSE M.Eng. students or permission of instructor.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Learning Outcomes:

- Demonstrate ability to apply theories of leadership to create an effective team environment in the workplace.
- Demonstrate improved networking, communication, and interpersonal skills associated with managing technical professionals and organizations
- Demonstrate improved ability to gather, assess, and use information to make informed and well-reasoned decisions.
- Identify personal weaknesses and demonstrate improvements in personal productivity.

Schedule of Classes (https://classes.cornell.edu/)

MSE 5010 - MEng Project - Ongoing (1-10 Credits)
Master of Engineering research project. Integration of technical, teamwork, and leadership skills to achieve a specific technical project goal defined by a project sponsor. MSE 5010 is for students who intend to complete their project in a later semester. Accordingly, success in MSE 5010 will be measured by progress against defined project goals. Students planning to complete course requirements in the current term should take MSE 5011.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Learning Outcomes:

- Demonstrate ability to apply technical knowledge to solving real-world problems.
- Demonstrate ability to use self-awareness and specific knowledge of principles of leadership and working on teams in achieving technical objectives.
- Demonstrate ability to prepare and deliver high-level reports, oral presentation, posters and other forms of communication about project expectations, goals, and results to a wide range of audiences.
- Demonstrate understanding of and adherence to rigorous ethical principles in planning and execution of the project and in presentation of the results.

Schedule of Classes (https://classes.cornell.edu/)

MSE 5011 - MEng Project - Terminal (1-12 Credits)
Master of Engineering research project. Integration of technical, teamwork, and leadership skills to achieve a specific technical project goal defined by a project sponsor. MSE 5011 is for students who intend to complete their project in the current semester. Accordingly, success in MSE 5011 will be measured by successful completion of all final project deliverables. Students planning to complete course requirements in a later term should take MSE 5010.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Learning Outcomes:

- Demonstrate ability to apply technical knowledge to solving real-world problems.
- Demonstrate ability to use self-awareness and specific knowledge of principles of leadership and working on teams in achieving technical objectives.
- Demonstrate ability to prepare and deliver high-level reports, oral presentation, posters and other forms of communication about project expectations, goals, and results to a wide range of audiences.
- Demonstrate understanding of and adherence to rigorous ethical principles in planning and execution of the project and in presentation of the results.

Schedule of Classes (https://classes.cornell.edu/)

MSE 5020 - Special Project (1-8 Credits)
Last Four Terms Offered: Spring 2024, Spring 2023, Fall 2017, Spring 2017
Schedule of Classes (https://classes.cornell.edu/)

MSE 5070 - Interdisciplinary Design Concepts (4 Credits)
Crosslisted with CHEME 5730
This course emphasizes entrepreneurial driven technology designs (forward engineering) by integrating mechanical, chemical, and materials engineering through the understanding of early stage product development complexities. These complexities include staging invention and innovation via the critical selection of materials, assessing product mechanics and processes for final product function, performance, reliability, cost and technical marketability. Students will attend lectures, participate in establishing a Tech Startup integrated into the Johnson School MBA mentoring program, attend startup design reviews, give a series of individual/group presentations, and write a startup issue paper.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 5120 - Mechanical Properties of Thin Films (3 Credits)
Crosslisted with MAE 5130
Last Four Terms Offered: Spring 2021, Spring 2019, Spring 2017, Spring 2015
Schedule of Classes (https://classes.cornell.edu/)

MSE 5210 - Properties of Solid Polymers (3 Credits)
Course provides a general introduction to this diverse field including synthetic and natural polymers for engineering applications. Covers structure, order, and dynamics integrating aspects of chemistry, physics, and engineering as needed to understand macromolecular materials. Relationships between structure and properties are elucidated from a materials science perspective. Examples from current literature are also discussed to expose students to the state-of-the-art in the field.
Prerequisites: MSE 2610 or permission of instructor. Corequisite: MSE 3010 or permission of instructor.
Last Four Terms Offered: Fall 2024, Fall 2023, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MSE 5230 - Physics of Soft Materials (3 Credits)
An introduction to general aspects of (i) structure, (ii) order and (iii) dynamics of soft materials /biomaterials. Typical representative materials discussed include polymers, thermo- and lyotropic liquid crystals, and gels. Following development of structural aspects of these materials, a general formalism for description of partially ordered systems in terms of orientation distribution functions will be introduced, including various techniques to measure these parameters. Finally, dynamics of soft materials will be discussed including transport and flow behavior, and aspects of the local dynamics. Structure, order and dynamic characterization techniques available at Cornell, such as NMR and x-ray scattering, will be emphasized.
Prerequisites: at least one of the following: MSE 2060, MSE 3010, MSE 3030, or permission of instructor.
Last Four Terms Offered: Fall 2023, Fall 2021, Spring 2017, Spring 2015
Schedule of Classes (https://classes.cornell.edu/)

MSE 5235 - Design of Soft Materials (3 Credits)
Crosslisted with CHEME 5235
Soft materials have unique properties, exploited widely by nature and industry. They are made from a variety of building blocks, including small molecules, macromolecules, and particles. These basic constituents can be arranged into a vast range of microstructures that determine their macroscopic material properties. This course will explore this broad material space, identify unifying scientific ideas, and explore practical strategies for their design. A top-down approach, which emphasizes their macroscopic behavior, will be combined with a bottom-up approach, that describes their microscopic structure and dynamics.
Prerequisites: CS 1110 or CS 1112, PHYS 1112, PHYS 2213, MSE 3030.
Last Four Terms Offered: Spring 2025, Spring 2024
Schedule of Classes (https://classes.cornell.edu/)

MSE 5240 - Synthesis of Polymeric Materials (3 Credits)
Advanced course covering synthesis of high molecular weight polymers and their structure-property tradeoffs. Introduction to basic physical characterization and the influence of molecular weight, molecular design and polymer architecture on properties and applications. Review of modern synthesis tools and strategies. Polymer families to be considered include: opto-electronic polymers, photopolymers, liquid crystal polymers, block polymers, biomimetic polymers, and common synthetic polymers. Synthesis tools include: step growth polymerization, chain growth polymerization, living polymerization and biosynthesis.
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2016, Fall 2013
Schedule of Classes (https://classes.cornell.edu/)

MSE 5310 - Introduction to Ceramics (3 Credits)
Covers ceramic processes and products, structure of ceramic crystals, structure of glasses, structural defects (point defects, dislocations), surfaces, interfaces and grain boundaries, diffusion in ionic materials (atomistic and phenomenological approach, relationships between diffusion and point defect structure), ceramic phase diagrams, phase transformations. Emphasizes physicochemical aspects of the different topics.
Prerequisites: MSE undergraduate program core courses through MSE 4050 or permission of instructor.
Last Four Terms Offered: Spring 2024, Spring 2023, Spring 2021, Spring 2019
Schedule of Classes (https://classes.cornell.edu/)

MSE 5320 - Glass: Structure, Properties and Modern Applications (3 Credits)
Crosslisted with CHEME 5320
Course develops a foundational understanding of the glassy state and nature of the glass transition. Introduces phenomenology, chemistry and structure of key oxide glass families, with an emphasis on silicate glasses and the interaction of oxide components. Recent advances in glass relaxation and the implications of the statistical nature of glass structure are also discussed. Contemporary and emerging applications in optical communication, displays, and electronics packaging are explored within the context of key optical, mechanical and thermal properties. Students will gain an understanding of modern glass theory, familiarity with glass technology, and practical know-how of a glass power user.
Prerequisites: MSE 2060, MSE 3030. Corequisite: MSE 3040 or equivalent background.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 5340 - Particulate Science and Engineering: Fundamentals and Applications (3 Credits)
This survey course is designed for senior undergraduates and graduate students in the fields of MSE, CBE, and MAE. Previous experience in particulate systems is not required. The course will focus on recent advances in particulate science and engineering (PSE) and its applications, which are relevant to particulate systems in various product applications. Lectures will draw from state-of-the-art research and industrial practice. Review of phenomenological modelling and numerical simulation methods focusing on discrete element method (DEM), and Finite Element Modelling (FEM). Students will participate in assigned group projects.
Enrollment Information: Enrollment limited to: Engineering seniors and graduate students.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Explain concepts relevant to the formation and formulation of particulate systems and various product applications based on principles of chemistry, physics, and mechanics.
- Identify key particle properties and their impact on processability and properties of the final product.
- Explain the significance of particle characterization in the design of particulate processes and products.
- Demonstrate understanding of population balance modeling by analyzing particulate processes for resolving new product pitfalls.

Schedule of Classes (https://classes.cornell.edu/)

MSE 5410 - Nanofabrication and Characterization of Electronics (3 Credits)
This course will give an introduction to modern nanofabrication technologies with emphasis on integrated circuits manufacturing. Thermal budget, scaling of geometry, pitch and registry and control of parametric yield will be used for integration guidelines. Physical principles and process modeling will be covered in lectures and labs will include a series of fabrication steps of lithography, metallization, plasma etching and annealing to produce semiconductor devices (Schottky diodes, pn junction diodes, MOS capacitors, and MOSFETs). Recent advances in nanofabrication will be briefly reviewed for their possible technology insertion and main integration challenges.
Prerequisites: MSE 2620 or ECE 3150, or equivalent that covers basics on semiconductors, and semiconductor devices, MATH 2930-MATH 2940, CHEM 2090.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 5411 - Nanofabrication and Characterization of Electronics Laboratory (1 Credit)
This course provides an introduction to nanofabrication technologies with emphasis on Si-based integrated circuits manufacturing as well as modern electronics based on GaN, 2D materials etc. The lab, primarily taught in the Cornell Teaching Cleanroom, includes basic fabrication steps of lithography, metallization, plasma etching and annealing. A series of devices will be fabricated: solar cells, MOS capacitors and transistors, 2D transistors, GaN HEMTs and LEDs.
Prerequisites: Prerequisite or corequisite: ECE 4360/MSE 5410, AEP 6620 or equivalents.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MSE 5425 - Properties, Characterization, and Applications of Nanomaterials (3 Credits)
Last Four Terms Offered: Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MSE 5430 - Thin-Film Materials Science (3 Credits)
Provides fundamental information on the deposition, properties, reaction, and evaluation of thin films.
Last Four Terms Offered: Spring 2025, Spring 2024, Fall 2019, Fall 2017
Schedule of Classes (https://classes.cornell.edu/)

MSE 5435 - Organic Electronics: Materials and Processing (3 Credits)
Organic electronics plays a crucial role in creating flexible, wearable, and biocompatible devices. This course explores the physical and chemical principles of organic electronics, the development of organic electronic materials, and state-of-the-art fabrication techniques. Structure-property relationships of organic electronic materials will be introduced. Various organic electronic devices, including field-effect transistors, solar cells, light-emitting diodes, electrochemical transistors, and sensors will be discussed. The course will cover the applications of organic materials in flexible, stretchable, and bioelectronic devices.
Prerequisites: materials chemistry at the level of MSE 3010, electronic properties at the level of MSE 2620.
Last Four Terms Offered: Spring 2024
Schedule of Classes (https://classes.cornell.edu/)

MSE 5440 - Soap Bubbles, Snowflakes, and Steps: Interfacial and Surface Phenomena in Materials Science (3 Credits)
Surface and interface phenomena play a critical role in the processing and performance of advanced materials. Students and the instructor will identify topics of joint interest that build on the fundamentals of surfaces and interfaces contained in the core materials science curriculum (diffusion and growth, surface structure and energy, adhesion, etc.) and that address phenomena such as interfacial electronic states, gas adsorption at surfaces and surface forces in air and liquid. Course content will be organized collaboratively with necessary background provided in lectures and readings, and with students contributing oral presentations and student-led active learning exercises.
Prerequisites: MSE 3010 and MSE 3030 or their equivalents. Corequisite: MSE 3040 or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MSE 5445 - Semiconductor Electronic and Photonics Devices (4 Credits)
Crosslisted with ECE 5360
The class develops the fundamentals of semiconductor electronic and photonic devices that power to-day's computation, communication, and memory industries. It relates the basics of pn junctions to their applications in solar cells, light emitting diodes, and lasers. Majority and minority carrier transport in heterostructure bipolar transistors is related to gain and speed limits of amplifiers for 5G communications and beyond. Schottky diodes and their applications in power electronics, and in field effect transistors of many flavors ranging from Silicon CMOS and FinFETs to GaN high electron mobility transistors are covered. Tunneling transport, flash memory, and DRAM devices are discussed. The course uses industrially relevant simulation tools, and the laboratory component gives students firsthand experience of measuring and appreciating the power and the limitations of semiconductor devices, and the reason for their revolutionary influence on our lives and society. MEng students and ECE PhD students who enroll in the 5000 level will be required to complete one extra design laboratory project compared to the 4000 level class.
Prerequisites: ECE 3150 or permission of instructor.
Last Four Terms Offered: Fall 2024, Fall 2023
Learning Outcomes:

- Obtain a well-grounded understanding of semiconductor device operation and advanced ideas in use in microelectronic industry and future generations of electronic circuitry.
- Learn through simulations, the aspects of physical behavior that analytic solutions are incomplete at and their more complete description of operational physics.
- Apply device fundamentals and simulation techniques to design modern nanoscale device structures.
- Develop comprehensive skills straddling electronics, integration, and devices as used in integrated circuits leading to effective communication of results.

Schedule of Classes (https://classes.cornell.edu/)

MSE 5510 - Materials Processing and Manufacturing (3 Credits)
Crosslisted with MAE 5240
Schedule of Classes (https://classes.cornell.edu/)

MSE 5520 - Advanced Topics in Metal Additive Manufacturing (3 Credits)
Crosslisted with MAE 6450
This course delves into three distinct categories of metal additive manufacturing processes, each governed by unique principles: solidification-based techniques, sintering-dependent methods, and solid-state bonding processes. Students will explore the intricacies of powder bed fusion and direct energy deposition, where solidification mechanisms play a pivotal role in controlling microstructure formation. The course will provide a comprehensive understanding of how factors such as heat transfer, cooling rates, and alloy composition influence solidification behavior in these processes. Additionally, students will examine indirect metal printing methods, including extrusion, stereolithography, and binder jetting, which rely on sintering to fuse metal powders together. Detailed discussions will cover the sintering process, its underlying mechanisms, and its impact on the final properties of printed parts. Furthermore, the course will delve into metal additive manufacturing processes based on solid-state bonding, such as cold spray and sheet lamination. Students will explore the principles of solid-state bonding, including diffusion bonding and mechanical interlocking, and understand how these processes are applied to join metal powders/sheets without melting. Throughout the course, major alloys commonly used in metal additive manufacturing, such as Ni-based alloys, titanium alloys, steels, and aluminum alloys, will be discussed. Common defects encountered in metal printing technologies, post-processing steps for defect removal, and in situ monitoring techniques for defect mitigation will also be covered, ensuring students gain a comprehensive understanding of quality assurance in metal AM.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to learn the fundamentals of additive manufacturing (AM) of polymers, metals, and ceramics.
- Students will be able to understand the operating principles, capabilities, and limitations of state-of-the-art AM methods, including fused deposition modeling, photopolymerization, laser melting/sintering, and material/binder jetting.
- Students will be able to understand properties of AM parts.
- Students will be able to realize industrial applications of AM.

Schedule of Classes (https://classes.cornell.edu/)

MSE 5530 - Materials Design and Processing for Industry (3 Credits)
Examine the fundamental theories of materials processes and manufacturing techniques, focusing on relevant process-structure-property relationships. Design processing routes and perform materials selection for desired properties and performance based on specific product requirements. Explore processing and design through several real-world case studies, presented by industry guests.
Last Four Terms Offered: Spring 2025
Schedule of Classes (https://classes.cornell.edu/)

MSE 5620 - Biomineralization: The Formation and Properties of Inorganic Biomaterials (3 Credits)
Crosslisted with BME 5620
This course will examine the wide variety of mineralized materials made by biological organisms including mollusk shells, sea urchins, mammalian bone and teeth, siliaceous sponges and diatoms, and magnetotactic bacteria. The focus will be on the molecular and biological mechanisms that lead to the formation of these materials as well as their unique mechanical, optical and optical properties.
Prerequisites: MSE 3010 or CHEM 1570 or CHEM 3570-CHEM 3580 or equivalent, or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2022, Spring 2018, Spring 2017
Schedule of Classes (https://classes.cornell.edu/)

MSE 5625 - Supramolecular Biophysics (3 Credits)
Crosslisted with PHYS 5520
This course will describe how biomolecules cooperate to assembly structures, build material, and process information. We will start by discussing stoichiometric assembly macromolecular complexes. Then, we'll discuss how biomolecules assemble to make 1D, 2D and 3D materials. These include, cytoskeletal filaments, phospholipid bilayers, and biomolecular condensates. Finally, we'll discuss how cells use these phenomena for control (regulation) and computation.
Prerequisites: statistical physics and/or thermodynamics; electrostatics; vector calculus; differential equations; basic scientific computing; introductory biology.
Enrollment Information: Primarily for: seniors and graduate students.
Last Four Terms Offered: Fall 2024
Schedule of Classes (https://classes.cornell.edu/)

MSE 5710 - Analytical Techniques for Material Science (3 Credits)
Crosslisted with BME 5710
Covers techniques used to determine the composition and structure of materials, both synthetic and biological. The aim is a level of understanding that allows students to choose suitable methods, to appreciate the physical basis of techniques so as to recognize their limitations, and to be able to interpret literature in specialty journals of the field. Modern approaches to determine composition, chemical structure and microstructure will be emphasized. It is not the intent of this course to train students as hands on users of particular instruments.
Prerequisites: MSE 2060.
Last Four Terms Offered: Spring 2020, Fall 2016, Fall 2014, Spring 2013
Schedule of Classes (https://classes.cornell.edu/)

MSE 5720 - Computational Materials Science (3 Credits)
This course provides students with an introduction to state-of-the-art computational methods in materials research with an emphasis on the atomic-scale and hands-on modeling using supercomputers. The course will focus primarily on first- principles quantum mechanical techniques (Density Functional Theory) for modeling extended (periodic) materials and properties, including electronic structure, vibrational properties, elastic properties, defects, surfaces, and interfaces. An important aspect of the course is the 'hands-on' lab component, in which students learn to set up, run and analyze the results of their calculations in a real high-performance computing environment as part of four project- based, multi-week homework assignments. Familiarity with the Schrödinger equation and basic quantum mechanics would be useful. Familiarity with a programming and/or scripting language would be helpful but not required.
Last Four Terms Offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 5730 - Probability, Statistics, and Data Analysis for the Physical Sciences (3 Credits)
Crosslisted with CHEME 5740
Statistical analysis of experimental data and processes, and the design of experiments are increasingly critical in both research and industrial environments. The course will review the fundamentals of probability and statistics, common probability distribution functions, data analysis and model parameter estimation, including characterization of sources of error and uncertainty, least-squares fitting, parameter correlation, as well as formal design of experiments (DOE) methodology.
Prerequisites: MATH 2930 and MATH 2940, some familiarity with statistics/probability.
Last Four Terms Offered: Fall 2023, Fall 2021, Fall 2019, Fall 2017
Schedule of Classes (https://classes.cornell.edu/)

MSE 5801 - Materials Structure and Electronic Properties (3 Credits)
Course is intended for first year graduate students in MSE, or graduate students in other fields, needing a solid foundation in structural and electronic properties for advanced study/research in materials. Atomic and molecular structure of crystalline, molecular, semicrystalline, and amorphous materials including: crystallography and symmetry; reciprocal lattice; order and disorder; point defects. Diffraction techniques for structural characterization: Bragg's Law, structure factors; thin film and size broadening; Debye scattering; symmetry breaking. Use of tensors to describe macroscopic physical properties and connections between symmetry and properties. Electrical properties of materials including: mechanisms of conduction; band structure and correlation with crystallography; modification of electrical properties in materials; charge transport across interfaces and semiconductor junctions; interaction of materials with light; fundamental semiconductor electronic devices (e.g. diodes, MOSFETS).
Prerequisites: engineering math and science equivalent to MATH 2940, PHYS 2214, and CHEM 2090.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will demonstrate an understanding of material structure including bonding, atomic structure (crystallography) on atomic and mesoscopic length scales, for a range of materials including metals, semiconductors, oxides, glasses, and polymers using conceptual frameworks and terminology common in materials science.
- Students will demonstrate understanding of tensor properties in materials and transformation of the properties across crystal systems.
- Students will identify and analyze electronic properties of a wide range of materials (metals, semiconductors, polymers) using underlying properties including crystal structure, band structure, temperature, and processing history.
- Students will explain and analyze the behavior of common electronic materials and devices (e.g. diodes, MOSFETs) using concepts of band theory, carrier populations, and transport properties.
- Students will demonstrate an understanding of the link between material structure and underlying band diagram properties.

Schedule of Classes (https://classes.cornell.edu/)

MSE 5802 - Materials Structure and Mechanical Properties (3 Credits)
Course is intended for first year graduate students in MSE, or graduate students in other fields, needing a solid foundation in the relationships between structure and mechanical properties in materials for advanced study and research. Microscopic structure of crystalline, molecular, amorphous and ordered non-crystalline solids, including point, line, and planar defects, twinning, and martensitic and pressure induced phase transformations. Mechanical properties of materials including: Use of tensors to describe stress, strain, and elastic constants, time-dependent elastic (anelastic) and plastic (creep) behavior, viscoelasticity, strengthening mechanisms, ductility, and toughness. Macroscopic mechanical properties are described in terms of atom-level mechanisms of elasticity, plasticity, and fracture.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will demonstrate an understanding of material microstructure including bonding and atom arrangements on atomic and mesoscopic length scales, and point line and planar defects, for a range of materials including metals, ceramics, and polymers using conceptual frameworks and terminology common in materials science.
- Students will demonstrate understanding of tensor fields (stress, strain) and tensor properties in materials and their representations in different coordinate systems.
- Students will identify and analyze mechanical properties of a wide range of materials (metals, ceramics, polymers) using fundamental mechanisms of elastic and plastic deformation, as well as fracture.

Schedule of Classes (https://classes.cornell.edu/)

MSE 5810 - Materials Chemistry (3 Credits)
Provides a molecular understanding of materials properties: introductory quantum chemistry, physical organic chemistry, crystal/ligand field theory, sol-gel chemistry, electrochemistry, and corrosion. Materials addressed include polymers, biopolymers, organic semiconductors, photoresists, silicate glasses, optical materials, and silica nanoparticles.
Prerequisites: CHEM 2090, MATH 2930, and ENGRD 2620.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 5820 - Mechanical Properties of Materials, Processing, and Design (3 Credits)
Relationship between microscopic mechanisms and macroscopic mechanical behavior of engineering materials, how mechanical properties can be modified, and criteria for selection and use of materials in design. Stress, strain and elastic constants as tensor quantities, viscoelasticity and damping, plastic deformation, creep deformation, fracture, and fatigue.
Prerequisites: MSE 2610 or equivalents.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 5830 - Thermodynamics of Condensed Systems (4 Credits)
Introduces the three laws of thermodynamics as the fundamental basis for thermal and chemical equilibrium, coupled with statistical mechanical interpretations for entropy. Applies these principles to understand the equilibrium behavior of matter, with a focus on condensed liquid and solid phases. Develops concepts of phase equilibria, phase diagrams, chemical reactions, solution behavior and electrochemistry. Includes an introduction to statistical mechanics and applications in ideal gas behavior, gas and crystal heat capacity, and electron Fermi-Dirac statistics. Applications and examples will be drawn from a range of sub-disciplines spanning metallurgy to polymers. Extended assignments and independent study of advanced concepts required.
Prerequisites: background equivalent to MATH 2930 and elements of MSE 2610, or permission of instructor.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 5840 - Kinetics, Diffusion, and Phase Transformation (3 Credits)
Phenomenological and atomistic theories of diffusion in metals, alloys, ionic compounds, semiconductors and polymers. Introduction to general transport theory and non-equilibrium thermodynamics. Kinetic effects in solidification and solid state transformations that determine structure and properties of materials including: interfaces and microstructure; nucleation, growth and coarsening; alloy solidification; and diffusional and diffusionless transformations in solids.
Prerequisites: MSE 3030 or equivalent, or permission of instructor.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MSE 5850 - Electronic, Magnetic, and Dielectric Properties of Materials (4 Credits)
Examines the electronic, magnetic, and dielectric properties of materials, including an understanding of the atomic level interactions that give rise to these properties. Topics include: use of tensors to describe equilibrium and transport macroscopic physical properties; connection between symmetry and properties; ferroelectrics, ferromagnets, and multiferroics; dispersion relations of phonons and electrons in solids; and effects of defects. Applications in microelectronics are discussed.
Prerequisites: MATH 2930 or MATH 2940, MSE 2060, MSE 2620, MSE 3010 or equivalents, PHYS 2213, or permission of instructor.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 5880 - The Science of Nanoparticles (3 Credits)
Last Four Terms Offered: Fall 2021, Fall 2019, Fall 2017, Fall 2014
Schedule of Classes (https://classes.cornell.edu/)

MSE 5998 - External Industrial Internship (1-2 Credits)
Off-campus internship with industry in which a student gains knowledge and experience in the field of materials science.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MSE 6010 - Chemistry of Materials (3 Credits)
Chemistry of materials with an emphasis on concepts of general applicability and modern developments in the materials field. The transition from atoms to molecules is developed by applying group theoretical approaches to chemical bonding, from molecules to materials by applying thermodynamic principles to self-assembly, and then to underpin these transitions with examples from the chemistry of low dimensional nanomaterials, sol-gel derived materials, surfactant and block copolymer self-assembly, mesoporous solids, and hierarchical materials. Throughout the course, examples from the current literature are discussed to familiarize students with the state-of-the-art in the field.
Prerequisites: CHEM 2070, or permission of instructor. Students should be comfortable with basics of organic chemistry.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Spring 2024, Fall 2022, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MSE 6030 - Thermodynamics of Materials (3 Credits)
This course aims to provide a comprehensive understanding on the concepts of statistical thermodynamics in materials science and engineering. Topics include fundamental statistical thermodynamics concepts such as ensembles, partition functions, distribution functions, free energies, and applications in gases, vibrations, electrons, phase transitions, alloys, surfaces, and defects. Emphasis will be placed on the fundamental governing principles and their applications to phenomena in materials.
Prerequisites: MSE 3030, MSE 3040, MSE 3050.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2021, Fall 2018
Schedule of Classes (https://classes.cornell.edu/)

MSE 6040 - Kinetics of Reactions in Condensed Matter (3 Credits)
This class covers the fundamental of kinetics in material with the focus on the microstructure. We will discuss the motion of atoms and molecules by diffusion, motion of dislocations and interfaces, morphological evolution due to capillary and applied mechanical forces, and phase transformations. This course if intended for graduate students.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2024, Spring 2022, Spring 2020, Spring 2015
Schedule of Classes (https://classes.cornell.edu/)

MSE 6050 - Physics of Semiconductors and Nanostructures (4 Credits)
Covers basic solid state and semiconductor physics relevant for understanding electronic and optical devices. Topics include crystalline structures, bonding in atoms and solids, energy bands in solids, electron statistics and dynamics in energy bands, effective mass equation, carrier transport in solids, Boltzmann transport equation, semiconductor homo- and hetero-junctions, optical processes in semiconductors, electronic and optical properties of semiconductor nanostructures, semiconductor quantum wells, wires, and dots, electron transport in reduced dimensions, semiconductor lasers and optoelectronics, high-frequency response of electrons in solids and plasmons.
Prerequisites: ECE 4060 or a course in basic quantum mechanics.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2021
Learning Outcomes:

- Learn basic principles of solid state and semiconductor physics needed to understand modern electronic and photonic devices.
- Learn how engineering materials and structures at the nanoscale enables novel electronic and photonic properties for a wide variety of engineering applications.
- Learn the relationship between basic science and engineering applications.

Schedule of Classes (https://classes.cornell.edu/)

MSE 6060 - Condensed Matter Structure (4 Credits)
This course provides an advanced understanding of the atomic structure of materials and how this structure is determined (characterization methods). Descriptions of structure in crystals, liquid, and amorphous solids/glasses. Short- and long-range order, microstructures, nanostructures. Brief review of fundamental aspects of bonding, lattices, quasicrystals, and x-ray scattering. The majority of the course is centered on techniques, such as diffraction methods, pair distribution (PDF/RDF), XPS, EELS, XANES, and EXAFS. Examples of application may include polymer structure, nanoparticles, nano-composite structures, surfaces, interfaces in semiconductors, structure of photonic materials, and biological materials. The morphology of crystals will be covered through the Wulff net and nanoparticle shape control. Articles by leaders within the fields of materials science, chemistry, and physics make up a large portion of the class.
Prerequisites: MSE 2060.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2023, Fall 2021, Fall 2020, Fall 2019
Schedule of Classes (https://classes.cornell.edu/)

MSE 6100 - Physical Metallurgy and Applications (3 Credits)
Last Four Terms Offered: Spring 2020, Fall 2018, Spring 2016, Spring 2014
Schedule of Classes (https://classes.cornell.edu/)

MSE 6160 - Advanced Crystallography: Symmetry, Order, and Complexity in Materials (3 Credits)
This course aims to provide a comprehensive understanding of crystal structures and their properties across length scales-from atomic to mesoscale structures-and across classes of materials (e.g., metals, oxides, polymer micelles, nanoparticles). After a quick review of crystallographic symmetry and notation, the course will follow an integrated approach, covering different crystal structure types and materials classes in a case-study-like manner, and the consequences of chemical and structural properties of the building blocks and emerging ordered structures. In the context of each class of structure types, the following aspects will be discussed: crystallographic nomenclature (symmetry groups), crystal structure geometry and topology (bond angles, coordination polyhedra, nets), types of order and disorder motifs (unit cells, modulations, stochasticity), crystal-chemical interpretation and chemical bonding (interactions between particles and resulting structural motifs), phase diagram context (phase stability, surrounding phases), structure-based properties (electric, mechanical, photonic, etc.). Topics include typical crystal structures in metals, oxides, ionic compounds, mesoscale systems, as well as complex periodic structures, aperiodic structures, non-periodic structures.
Prerequisites: basic understanding of crystal structure and symmetry, equivalent to MSE 2060 or MSE 5801.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2022
Learning Outcomes:

- Apply crystallographic nomenclature to describe crystal structures.
- Create graphical and numerical representations of crystal structures.
- Identify crystal structure types and relate phases to geometrical equivalents across length scales and classes of materials.
- Demonstrate an understanding of the relationship between materials geometry and structure-based materials properties.

Schedule of Classes (https://classes.cornell.edu/)

MSE 6650 - Principles of Tissue Engineering (3 Credits)
Crosslisted with BME 6650, MAE 6650
Covers introductory concepts in tissue engineering, including polymeric biomaterials used for scaffolds, mechanisms of cellbiomaterial interaction, biocompatibility and foreign body response, cell engineering, and tissue biomechanics. This knowledge is applied to engineering of several bodysystems, including the musculoskeletal system, cardiovascular tissues, the nervous system, and artificial organs. These topics are discussed in the context of scale-up, manufacturing, and regulatory issues.
Enrollment Information: Enrollment limited to: graduate students or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2017, Spring 2015
Schedule of Classes (https://classes.cornell.edu/)

MSE 6720 - Advanced X-ray Characterization (3 Credits)
Last Four Terms Offered: Spring 2023, Spring 2021, Spring 2019
Schedule of Classes (https://classes.cornell.edu/)

MSE 7930 - Peer Mentoring and Leadership Essentials (1 Credit)
Crosslisted with ENGRG 7930, CHEME 6930
This course develops fundamental communication, coaching, mentorship and leadership skills for PhD students. It is designed specifically for PhD mentors in the Ezra's Bridge program; however, the course is appropriate for all PhD students who wish to be more effective lab members and leaders.
Enrollment Information: Enrollment limited to: PhD students in Ezra's Bridge Program. Additional seats open to PhD students in any STEM field.
Last Four Terms Offered: Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Demonstrate competence in core skills of peer coaching and mentoring.
- Demonstrate competence in creating an inclusive and psychologically safe academic work environment.
- Demonstrate competence in proactive leadership communication skills.

Schedule of Classes (https://classes.cornell.edu/)

MSE 8000 - Research in Materials Science (1-12 Credits)
Independent research in materials science under the guidance of a member of the staff.
Enrollment Information: Enrollment limited to: MS and Ph.D. students.
Exploratory Studies: (CU-UG)

Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MSE 8005 - Principles and Practices of Graduate Research (1 Credit)
A series of discussion-based workshops that help incoming PhD students in materials science and engineering form a cohort and succeed in their first year and beyond. Professional development topics include strategies for: matching and communicating with a research advisor, preparing and practicing for the PhD qualifying exam, transitioning from undergraduate study to graduate study, navigating professional responsibilities, persuasive writing for fellowship and funding applications, career planning and goal setting with individual development plans, and communicating professionally with elevator pitches. Qualifying exam and fellowship preparation create a framework for building personal and professional connections with other students.
Enrollment Information: Enrollment limited to: first-year MSE Ph.D. students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Demonstrate understandings of research expectations and best practices.
- Demonstrate abilities to sustain professional developments at the appropriate level.
- Master research communications both in writing and through oral presentations.

Schedule of Classes (https://classes.cornell.edu/)

MSE 8010 - Materials Science and Engineering Colloquium (0.5 Credits)
Lectures by visiting scientists, Cornell staff members, and graduate students on subjects of interest in materials sciences, especially in connection with new research.
Enrollment Information: Enrollment limited to: MSE Ph.D., MS, and MEng students.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MSE 8020 - Materials Science Research Group Seminars (1.5 Credits)
Short presentations on research in progress by students and staff.
Enrollment Information: Enrollment limited to: graduate students involved in research projects.
Exploratory Studies: (CU-UG)

Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)