MATERIALS SCIENCE AND ENGINEERING

Our Website (http://www.mse.vt.edu)

Overview

Materials engineers and scientists study the structure and properties of engineering materials on scales ranging from the atomic through the microscopic to the macroscopic. These materials include ceramics and glasses, metals, polymers, composites, biomaterials, nanomaterials, semiconductors, and electronic, magnetic, and photonic materials. Materials engineers develop new materials, improve traditional materials, and manufacture materials economically through synthesis, processing, and fabrication. They seek to understand physical and chemical phenomena in material structures and to measure and characterize materials properties of all kinds including mechanical, electrical, optical, magnetic, thermal, and chemical. They predict and evaluate the performance of materials as structural or functional elements in engineering systems and structures. They work in teams with engineers in other disciplines in selecting, designing and processing materials for optimal performance.

Significant opportunities exist for graduates in the aerospace, automobile, transportation, medical, microelectronics, telecommunications, chemical, petroleum, energy storage, power generation, and energy conservation industries, as well as within the basic industries producing materials--for example, the copper, aluminum, steel, ceramics, glass, and polymer industries. Opportunities also exist in government-operated engineering centers and research laboratories. Graduates work in entry level engineering, manufacturing, materials selection and design, quality assurance and control, research and development, technical consulting, management, and sales and marketing. Graduates have an excellent background for continuing education in science, engineering, medicine, law (e.g. patent law), and business.

Accreditation

The Bachelor of Science in Materials Science and Engineering (BSMSE) degree program at Virginia Tech is accredited by the Engineering Accreditation Commission of ABET (http://www.abet.org/), under the commission's General Criteria and Program Criteria for Materials, Metallurgical, Ceramics and Similarly Named Engineering Programs.

Program Educational Objectives

The goal of the BS degree program in MSE is to provide the educational foundation that enables alumni to pursue their personal career objectives. Historically, the majority of our alumni become valued members of industrial and/or research teams within the field of materials science or related technical disciplines while a smaller percentage pursue graduate education or other personal career objectives.

The program educational objectives for the BSMSE degree program are to produce alumni who are:

- effective communicators with written, oral, and visual media;
- able to apply critical thinking skills to engineering and research problems; and
- effective learners able to apply technical tools, techniques, and knowledge specific to their field of employment or graduate studies.

Student Outcomes

Upon completion of the undergraduate program curriculum in Materials Science and Engineering, students will attain the following outcomes:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Curriculum

Students typically enter the MSE Department following completion of their first-year studies within the College of Engineering, as administered by the Department of Engineering Education (ENGE); a description of required first year coursework can be found within the ENGE section of this catalog.

In addition to foundation courses in MSE, students tailor an individualized program of elective study. 12 credits of technical electives will be selected to emphasize certain subdisciplines of MSE (e.g., metals, ceramics, polymers, electronic materials, composites, biomaterials, nanomaterials, etc.) or to prepare for a career in an engineering application area. Course-work totals 126 credit hours as detailed in the University Catalog at Program Explorer | Virginia Tech (https://catalog.vt.edu/program-explorer/).

The undergraduate curriculum contains a nationally recognized integrated program of instruction in engineering communication including writing, public speaking, proposal preparation, reporting, research skills, critical and creative thinking, and graphical presentation. More information regarding this unique program can be found at https://mse.vt.edu/Programs.html

The undergraduate program culminates with a two-semester team-oriented engineering design capstone project in which the students address a significant problem in their area of special interest.

The MSE students have pursued various minors including Green Engineering, Chemistry, Mathematics, Music, Nuclear, and various others.

Students of MSE can participate in the cooperative education program in which qualified students may alternate semesters of study with

semesters of professional employment. (www.career.vt.edu/experience/ceip.html (http://www.career.vt.edu/experience/ceip.html))

MSE also participates in the university honors degree options (see www.honorscollege.vt.edu (http://www.honorscollege.vt.edu)).

Study abroad opportunities are also available Studying Abroad | Global Education Office | Virginia Tech (https://www.globaleducation.vt.edu/students/Outbound.html).

- Materials Science and Engineering Major (https://catalog.vt.edu/undergraduate/college-engineering/materials-science-engineering/materials-science-engineering-bs/)

Head: A. Noble (interim)
Jack E. Cowling Professor: D.D. Viehland
Professors: S.K. Kodambaka, G.Q. Lu, M. Murayama, G.R. Pickrell, and W.T. Reynolds Jr.
Associate Professors: A.O. Aning, L.V. Asryan, X. Bai, W. Cai, S.G. Corcoran, C. Hin, C. Tallon, A.R. Whittington[1], and H. Yu.
Assistant Professors: T. Pham and T. Rost
Collegiate Associate Professor: T.W. Staley
Collegiate Assistant Professor: H. Kindlund and H.M. Elmkharram
Associate Professors of Practice: A.P. Druschitz, and S. McGinnis
Assistant Professor of Practice: C.B. Burgoyne
Research Associate Professors: J-F. Li and C.T.A. Suchicital
Research Assistant Professor: Y. Zhu
Professors Emeritus: J.J. Brown Jr., R.O. Claus, N.E. Dowling, D. Farkas, G.V. Gibbs, D.P.H. Hasselman, and R.W. Hendricks
Affiliated Faculty: R.C. Batra, M.J. Bortner, A. Brand, S.W. Case, R.V. Davalos, C. DiMarino, P. Dove, S. Emori, Y. Fu, A. Goldstein, J.R. Heflin, X. Jia, B. Johnson, B. Lattimer, G. Liu, F. Lin, R. Mahajan, R.B. Moore, A. Morris, K. Ngo, K. Park, L. Quan, N.L. Ross, J. Song, M. Van Dyke, C.B. Williams, R.H. Yoon, and Y. Zhang.

Undergraduate Course Descriptions (MSE)

MSE 1004 - Materials In Todays World (1 credit)
An introductory course designed for the student with a basic high school science background who wishes to understand and learn about the exciting materials developments which are affecting us all in todays world. The course will introduce the structures and properties of metals, ceramics, polymers (plastics), composites, and materials for electronic and optical applications. Students will also gain an appreciation for the processing and design limitations of materials used in everyday applications.
Instructional Contact Hours: (1 Lec, 1 Crd)

MSE 1014 - The Science of Materials in Everyday Life (3 credits)
Introduction to the science of materials using everyday applications in modern society from medicine, transportation, sports, art, music, infrastructure, and electronics. Discussion of metals, ceramics, plastics, biomaterials, and hybrid materials based on the fundamental science dictating their structure properties, and processing. Considerations of tradeoffs between environmental sustainability, ethical and societal issues, and economics for materials choices.
Pathway Concept Area(s): 4 Reasoning in Natural Sci., 10 Ethical Reasoning
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 2014 - Materials Engineering Transition (1 credit)
Supplemental coverage of introductory topics not included in courses delivered to non-MSE majors.
Prerequisite(s): MSE 2034 or MSE 3094 or AOE 3094
Instructional Contact Hours: (1 Lec, 1 Crd)

MSE 2034 - Elements of Materials Engineering (3 credits)
This course is designed to introduce the non-MSE student to the structures and properties of metals, ceramics, polymers, and composites. In addition, students will gain an understanding of the processing and design limitations of these materials, as well as being introduced to new classes of materials being developed to meet the ever expanding range of material requirements. Non-MSE majors only.
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 2044 - Fundamentals of Materials Engineering (4 credits)
This course is designed to introduce the MSE major to the structures and properties of metals, ceramics, polymers, composites, and electronic materials. Students will also gain an understanding of the processing and design limitations of materials. Topics fundamental to the further study of materials, such as crystal structures, phase diagrams, and materials design and processing will be emphasized as foundations for future MSE courses.
Prerequisite(s): CHEM 1035
Corequisite(s): PHYS 2305
Instructional Contact Hours: (4 Lec, 4 Crd)

MSE 2054 - Fundamentals of Materials Science (3 credits)
Introduces MSE majors to fundamental underlying concepts governing phase equilibrium, microstructure, electronic properties of materials, and transport phenomena as a foundation to understanding materials behavior and processing.
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 2114 - Math Programming MSE I (1 credit)
Basic computational and graphical functions in mathematics oriented programming languages using data and engineering examples from the field of Materials Science. Students apply general methods to problems of their choice through mini- projects.
Prerequisite(s): MSE 2044
Instructional Contact Hours: (1 Lec, 1 Crd)

MSE 2884 - Materials Engineering Professional Development I (1 credit)
Topics on professional, communications, and leadership skills in entering the engineering workplace; building and presenting qualifications for professional development; expanding the professional network; and ethical, diversity, inclusion, and equity in the engineering workplace. Career gap analysis, team dynamics, resumes, job interviews, cover letters, scholarship essays, personal statements, professional development portfolios, case studies, poster presentations. Pre: Sophomore standing in the MSE major.
Pathway Concept Area(s): 1A Discourse Advanced, 10 Ethical Reasoning
Instructional Contact Hours: (1 Lec, 1 Crd)

MSE 2974 - Independent Study (1-19 credits)
Instructional Contact Hours: Variable credit course

MSE 2974H - Independent Study (1-19 credits)
Instructional Contact Hours: Variable credit course

MSE 2984 - Special Study (1-19 credits)
Instructional Contact Hours: Variable credit course

MSE 2984D - Special Study (1-19 credits)
Pathway Concept Area(s): 4 Reasoning in Natural Sci.
Instructional Contact Hours: Variable credit course

MSE 2994 - Undergraduate Research (1-19 credits)
Instructional Contact Hours: Variable credit course

MSE 2994H - Undergraduate Research (1-19 credits)
Instructional Contact Hours: Variable credit course

MSE 3044 - Transport Phenomena in MSE (3 credits)
Mass transport (continuum and atomistic diffusion), heat transport and fluid flow (momentum transport). Analytical and computer based methods for solving transport problems.
Prerequisite(s): MSE 2044 and MATH 2214
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 3054 - Mechanical Behavior of Materials (3 credits)
Mechanical properties and behavior of engineering materials subjected to static, dynamic, creep, and fatigue loads under environments and stress states typical of service conditions; biaxial theories of failure; behavior of cracked bodies; microstructure-property relationships and design methodologies for homogeneous and composite materials.
Prerequisite(s): ESM 2204 and (MSE 2034 or MSE 2044 or MSE 3094 or AOE 3094 or CEE 3684)
Instructional Contact Hours: (3 Lec, 3 Crd)
Course Crosslist: ESM 3054

MSE 3064 - Mechanical Behavior of Materials Laboratory (1 credit)
Laboratory experiments on behavior and mechanical properties of solid materials. Tension, compression, bending, hardness, nano-indentation, and impact tests; behavior of cracked bodies; fatigue and crack growth tests; creep deformation; microstructure-property relationships; laboratory equipment, instrumentation, and computers.
Prerequisite(s): ESM 2204
Corequisite(s): MSE 3054
Instructional Contact Hours: (3 Lab, 1 Crd)
Course Crosslist: ESM 3064

MSE 3104 - Mineralogy (3 credits)
Principles of modern mineralogy, crystal chemistry, and crystallography, with emphasis on mineral atomic structure and physical property relationships, mineralogy in the context of geology, geochemistry, environmental science and geophysics, phase equilibria, mineral associations, and mineral identification, and industrial applications of minerals. There are three required field trips during the semester.
Corequisite(s): CHEM 1035 or CHEM 1055 or (ISC 1106 and ISC 1116)
Instructional Contact Hours: (2 Lec, 3 Lab, 3 Crd)
Course Crosslist: GEOS 3504

MSE 3114 - Mathematics Programming in Materials Science II (1 credit)
Advanced computational and graphical methods in mathematics oriented programming languages. Students develop programs that solve and/or provide visualizations of solutions to materials science and engineering problems.
Prerequisite(s): MSE 2114
Instructional Contact Hours: (1 Lec, 1 Crd)

MSE 3134 - Crystallography and Crystal Structures (3 credits)
Provides a comprehensive foundation in crystallography including lattices, point groups, space groups, reciprocal lattices, properties of x-rays, and electron density maps, all leading to a formal description of structures and an interpretation of the published crystallographic data.
Prerequisite(s): MSE 2044
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 3204 - Fundamentals of Electronic Materials (3 credits)
Introduction to the electrical, magnetic, and optical properties of solid-state materials. Development of atomic scale models for physical phenomena that are observable at the macroscopic scale. Connection is made between basic materials properties and the operational characteristics of selected solid-state devices.
Prerequisite(s): MSE 2054 and PHYS 2306
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 3304 - Physical Metallurgy (3 credits)
Deformation of crystalline solids and its relationship to crystal structure and crystal defects: crystal structures of metals, dislocations and plastic deformation, vacancies, recovery, recrystallization, grain growth, deformation twinning and martensite.
Prerequisite(s): MSE 2044
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 3314 - Materials Laboratory I (1 credit)
Sample preparation for materials characterization techniques including various types of microscopy, spectroscopy, diffraction, and hardness testing. Instruction in the use of heat treating equipment and polishing and chemical etching procedures.
Prerequisite(s): MSE 2044
Instructional Contact Hours: (3 Lab, 1 Crd)

MSE 3324 - Elementary Metal Casting Laboratory (1 credit)
Introduction to metal casting processes; gating, risering, molding and puring. Hands-on experience. Emphasis on safe foundry practices. Oral and written reports are required.
Prerequisite(s): (MSE 2034 or MSE 2044) and ISE 2214
Corequisite(s): MSE 3354
Instructional Contact Hours: (3 Lab, 1 Crd)

MSE 3334 - Test Methods for Foundry Laboratories (2 credits)
The properties of foundry sand, molten metal and castings are measured using standard laboratory test procedures. Safe foundry practices are emphasized. Oral and written reports are required.
Prerequisite(s): (MSE 2034 or MSE 2044) and ISE 2214
Corequisite(s): MSE 3354
Instructional Contact Hours: (1 Lec, 2 Lab, 2 Crd)

MSE 3354 - Foundry Safety (1 credit)
Provides comprehensive training in foundry safety procedures and policies. (May register multiple times).
Prerequisite(s): (MSE 2034 or MSE 2044) and ISE 2214
Corequisite(s): 3324 or 3334 or 4324.
Instructional Contact Hours: (2 Lec, 1 Crd)

MSE 3884 - Materials Engineering Professional Development II (1 credit)
Teamwork, ethical, professional, and communication practices in collaborative engineering environments; identification of areas of interest for potential senior design capstone projects; discipline-specific preliminary research in preparation for senior design projects: motivations and needs identification, broader impact (economic, social, environmental, and global), relevant theoretical concepts and methodologies, ethical engineering considerations, management logistic such identification of facilities and equipment, risk and safety analysis, critical paths and project timelines; basic project and time management; collaborative communications in written and oral form, personal professional development plans. Extends the basic treatment of these topics given in MSE 2884. Pre: Junior standing in the MSE major.
Prerequisite(s): MSE 2884
Pathway Concept Area(s): 1A Discourse Advanced, 10 Ethical Reasoning
Instructional Contact Hours: (1 Lec, 1 Crd)

MSE 3954 - Study Abroad (1-6 credits)
Instructional Contact Hours: (1-6 Lec, 1-6 Crd)

MSE 4034 - Thermodynamics of Materials Systems (3 credits)
Topics in thermodynamics on the solution of materials selection and design related problems such as materials stability at high temperatures and in corrosive chemical environments. Thermodynamic principles important in controlling equilibrium in single component systems and multicomponent solid solutions and in establishing the thermodynamic driving force in kinetic processes which are important in materials processing unit operations. Estimation of thermodynamic properties and equilibrium calculations in multicomponent and multiphase systems.
Prerequisite(s): MSE 2044
Corequisite(s): CHEM 1036
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4044 - Powder Processing (3 credits)
Processing methods associated with powder synthesis, characterization, colloidal processing, and forming of powder compacts. Theory of solid state and liquid phase sintering.
Prerequisite(s): MSE 3044
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4055 - Materials Selection and Design I and II (3 credits)
4055: Selection of materials for engineering systems, based on constitutive analyses of functional requirements and material properties. 4056: The role and implications of processing on material selection.
Prerequisite(s): (MSE 3204 and MSE 3304) or (MSE 3204 and MSE 4414) or (MSE 3204 and MSE 4554) or (MSE 3304 and MSE 4414) or (MSE 3304 and MSE 4554) or (MSE 4414 and MSE 4554)
Corequisite(s): MSE 3054
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4056 - Materials Selection and Design I and II (3 credits)
4055: Selection of mateials for engineering systems, based on constitutive analyses of functional requirements and material properties. 4056: The role and implications of processing on material selection.
Prerequisite(s): MSE 4055
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4075 - Senior Design Laboratory (1 credit)
A capstone design course centered around an open-ended, faculty-advised senior project involving the design of a process, material, or a technique for solving a technological problem. Senior standing in MSE required.
Prerequisite(s): MSE 4644
Corequisite(s): MSE 4055, MSE 4085
Instructional Contact Hours: (3 Lab, 1 Crd)

MSE 4076 - Senior Design Laboratory (2 credits)
A capstone design course centered around an open-ended, faculty-advised senior project involving the design of a process, material, or a technique for solving a technological problem. Senior standing in MSE required.
Prerequisite(s): MSE 4075
Corequisite(s): MSE 4086
Instructional Contact Hours: (6 Lab, 2 Crd)

MSE 4085 - Senior Capstone Recitation (2 credits)
Topics in engineering professional practice, project planning and reporting, including discussion and presentation of proposals, interim and project reports. Instruction in environmental, social, and economic impacts of engineering; design theory and analysis; ethics, continuous learning, and global issues. Capstone course runs in parallel with faculty-advised Senior Design Laboratory. 4085: Emphasis on project planning and management techniques, teamwork strategies, literature research, and technical communication style. 4086: Continuing development of technical documents, with emphasis on professional communication to various audience formats. Additional focus on broader impacts of technical projects, including social, economic, environmental, ethical, and global contexts. Pre: Senior standing in MSE.
Prerequisite(s): MSE 3884
Corequisite(s): 4075 or 4095H for 4085; 4076 or 4096H for 4086. (2H,2C) for 4085. (1H,1C) for 4086.
Pathway Concept Area(s): 1A Discourse Advanced, 10 Ethical Reasoning
Instructional Contact Hours: (2 Lec, 2 Crd)

MSE 4085H - Senior Capstone Recitation (2 credits)
Topics in engineering professional practice, project planning and reporting, including discussion and presentation of proposals, interim and project reports. Instruction in environmental, social, and economic impacts of engineering; design theory and analysis; ethics, continuous learning, and global issues. Capstone course runs in parallel with faculty-advised Senior Design Laboratory. 4085: Emphasis on project planning and management techniques, teamwork strategies, literature research, and technical communication style. 4086: Continuing development of technical documents, with emphasis on professional communication to various audience formats. Additional focus on broader impacts of technical projects, including social, economic, environmental, ethical, and global contexts. Pre: Senior standing in MSE.
Prerequisite(s): MSE 3884
Corequisite(s): 4075 or 4095H for 4085; 4076 or 4096H for 4086. (2H,2C) for 4085. (1H,1C) for 4086.
Instructional Contact Hours: (2 Lec, 2 Crd)

MSE 4086 - Senior Capstone Recitation (1 credit)
Topics in engineering professional practice, project planning and reporting, including discussion and presentation of proposals, interim and project reports. Instruction in environmental, social, and economic impacts of engineering; design theory and analysis; ethics, continuous learning, and global issues. Capstone course runs in parallel with faculty-advised Senior Design Laboratory. 4085: Emphasis on project planning and management techniques, teamwork strategies, literature research, and technical communication style. 4086: Continuing development of technical documents, with emphasis on professional communication to various audience formats. Additional focus on broader impacts of technical projects, including social, economic, environmental, ethical, and global contexts. Pre: Senior standing in MSE.
Prerequisite(s): MSE 4085
Corequisite(s): 4075 or 4095H for 4085; 4076 or 4096H for 4086. (2H,2C) for 4085. (1H,1C) for 4086.
Pathway Concept Area(s): 1A Discourse Advanced, 10 Ethical Reasoning
Instructional Contact Hours: (1 Lec, 1 Crd)

MSE 4086H - Honors Senior Capstone Recitation (1 credit)
Topics in engineering professional practice, project planning and reporting, including discussion and presentation of proposals, interim and project reports. Instruction in environmental, social, and economic impacts of engineering; design theory and analysis; ethics, continuous learning, and global issues. Capstone course runs in parallel with faculty-advised Senior Design Laboratory. 4085: Emphasis on project planning and management techniques, teamwork strategies, literature research, and technical communication style. 4086: Continuing development of technical documents, with emphasis on professional communication to various audience formats. Additional focus on broader impacts of technical projects, including social, economic, environmental, ethical, and global contexts. Pre: Senior standing in MSE.
Prerequisite(s): MSE 4085
Corequisite(s): 4075 or 4095H for 4085; 4076 or 4096H for 4086. (2H,2C) for 4085. (1H,1C) for 4086.
Pathway Concept Area(s): 1A Discourse Advanced, 10 Ethical Reasoning
Instructional Contact Hours: (1 Lec, 1 Crd)

MSE 4095H - Honors Senior Design-Laboratory (3 credits)
Two-semester MSE capstone design course centered around an open-ended, faculty-advised senior honors project involving the design of a process, material, or a technique for solving a technological problem. Outcomes and work effort are consistent with that expected of honors students. MSE 4095H: Literature search, planning and proof-of-concept studies of assigned project. Individual preparation and presentation of an original senior honors thesis related to a team project in which the students also participate. Presentation of detailed project plan to faculty. MSE 4096H: Execution of proposed project, analysis of results and preparation of journal-quality presentation of results. Oral presentation of results to MSE faculty and students. Enrollment in University Honors and senior standing in MSE required.
Prerequisite(s): MSE 4644
Corequisite(s): MSE 4055, MSE 4085
Instructional Contact Hours: (9 Lab, 3 Crd)

MSE 4096H - Honors Senior Design Laboratory (3 credits)
Two-semester MSE capstone design course centered around an open-ended, faculty-advised senior honors project involving the design of a process, material, or a technique for a solving a technological problem. Outcomes and work effort are consistent with that expected of honors students. MSE 4096H: Execution of proposed project, anaylsis of results and preparation of journal-quality presentation of results. Oral presentation of results to MSE faculty and students. Enrollment in University Honors and senior standing in MSE required.
Prerequisite(s): UH 4095H
Corequisite(s): MSE 4086
Instructional Contact Hours: (9 Lab, 3 Crd)

MSE 4164 - Principles of Materials Corrosion (3 credits)
Introduction to the scientific principles of materials corrosion and corrosion protection. Topics include: thermodynamics of materials corrosion, including potential- PH (Pourbaix) diagrams, kinetics of corrosion reactions and mixed potential theory, types of corrosion (uniform, galvanic, crevice, pitting, fatigue, stress corrosion cracking, intergranular, and hydrogen embrittlement), material/environmental factors that promote or prevent the various types of corrosion, and methods and techniques of corrosion testing.
Corequisite(s): MSE 4034
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4174 - Corrosion and Degradation of Materials Laboratory (1 credit)
Introduction to experimental techniques and principles used to study the effects of environmental exposure on various contemporary advanced materials systems. Emphasis on creation and measurement of property variations in engineered materials caused by time and chemical or energetic stimuli, and effective communication of these results.
Prerequisite(s): MSE 4034 and MSE 3314 and MSE 4424
Corequisite(s): MSE 3044
Instructional Contact Hours: (3 Lab, 1 Crd)

MSE 4224 - Electronic, Magnetic, and Optical Properties of Materials Laboratory (1 credit)
Introduction to experimental techniques used to study the electronic, magnetic, and optical properties of contemporary advanced materials systems; property variations made possible by composition and processing of engineered materials; and interaction of fields with materials – including effective communication of these results.
Prerequisite(s): MSE 3204 and MSE 3314 and MSE 4424
Instructional Contact Hours: (3 Lab, 1 Crd)

MSE 4234 - Semiconductor Processing (3 credits)
Manufacturing practices used in silicon integrated circuit fabrication and the underlying scientific basis for these process technologies. Physical models are developed to explain basic fabrication steps, such as substrate growth, thermal oxidation, dopant diffusion, ion implantation, thin film deposition, etching, and lithography. The overall CMOS integrated circuit process flow is described within the context of these physical models.
Prerequisite(s): ECE 2214
Instructional Contact Hours: (3 Lec, 3 Crd)
Course Crosslist: ECE 4234

MSE 4304 - Metals and Alloys (3 credits)
This course covers the production, properties and uses of commercially important metals and alloys. The influence of structure, chemistry, and processing upon the properties of metals is emphasized. Alloy selection is discussed. Mechanical, electrical, thermal and chemical characteristics of ferrous and nonferrous alloys are studied.
Prerequisite(s): MSE 2034 or MSE 2044
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4305 - Physical Metallurgy and Modeling of Metal Casting (3 credits)
4305: Casting processes; solidification and its influences on the structure and chemistry of castings; role of fluid flow and heat transfer in mold design; origin and control of casting defects. 4306: Design, layout, and modeling of metal components cast from aluminum, bronze, iron and steel; design of metal running systems; modeling of solidification process.
Prerequisite(s): MSE 3304
Corequisite(s): 3044 or ME 3304 for 4306.
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4306 - Physical Metallurgy and Modeling of Metal Casting (3 credits)
4305: Casting processes; solidification and its influence on the structure and chemistry of castings; role of fluid flow and heat transfer in mold design; origin and control of casting defects. 4306: Design, layout, and modeling of metal components cast from aluminum, bronze, iron and steel; design of metal running systems; modeling of solidification processes.
Prerequisite(s): (MSE 2034 or MSE 2044) and MSE 3324
Corequisite(s): 3044 or ME 3304 for 4306.
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4314 - Bladesmithing (3 credits)
Introduction to bladesmithing processes. Hands-on experience with heating metal, visual temperature measurement, manual hammer forging, forge welding, cooling metal, and heat treatment. Emphasis on safe forging and bladesmithing practices.
Corequisite(s): MSE 3304, MSE 3354
Instructional Contact Hours: (2 Lec, 3 Lab, 3 Crd)

MSE 4324 - Advanced Metal Casting Laboratory (2 credits)
Advanced metal casting processes; no-bake sand molds; investment casting; rapid prototyping; melting and casting of aluminum, bronze, iron and steel. Casting finishing including shot and sand blasting. Hands-on experience. Emphasis on safe foundry practices. Oral and written reports are required.
Prerequisite(s): MSE 3324
Corequisite(s): MSE 3354
Instructional Contact Hours: (1 Lec, 3 Lab, 2 Crd)

MSE 4334 - Applied Materials Analysis (3 credits)
Fundamental materials theory applied to structure-property relationships in materials science and engineering through basic characterization techniques. Demonstrations, lab exercises, and practical application of modern characterization techniques such as Scanning and Transmission Electron Microscopy (SEM, TEM), Focused Ion Beam (FIB), and Atomic Force Microscopy (AFM).
Prerequisite(s): MSE 2044 and (MSE 3314 or MSE 4424)
Instructional Contact Hours: (2 Lec, 3 Lab, 3 Crd)

MSE 4384 - Nuclear Materials (3 credits)
An introduction to materials for nuclear applications with emphasis on fission reactors. Fundamental radiation effects on materials; material properties relevant to structural, moderator, reflector, blanket, coolant, control shielding and safety systems; processes such as nuclear fuel cycles, fuel enrichment and reprocessing; and related structural systems.
Prerequisite(s): (MSE 3044 or ME 3304) and (MSE 3054 or ESM 3054 or ME 3614)
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4394 - Introduction to Molecular Dynamics Simulation (3 credits)
Background of molecular dynamics simulation method. Fundamental molecular dynamics principles, algorithms and components (atomic structure, periodic boundary conditions, interatomic potentials, equations of motion of atoms, statistical ensembles, integration of equations of motion). Implementation of algorithms into codes. Simulations of the time evolution of atoms, particles, or molecules under static or varying thermodynamic conditions and external loads. Connection between atom trajectories and evolution of the physical property of the simulation system with statistical mechanics principles. Hands-on case studies using molecular dynamics simulation package, LAMMPS. Prior knowledge of a programming language such as Fortran, C, C++, Matlab, Mathematica, Python, Java is highly recommended. Pre: Junior standing.
Prerequisite(s): MSE 2034 or MSE 2044
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4414 - Physical Ceramics (3 credits)
Study of the relationships between the physical properties (thermal, optical, mechanical, electrical and magnetic) and the structure and composition of ceramics at the atomic and microscopic level as affected by processing and service environment. Emphasis will be placed on application and design using structural ceramics.
Prerequisite(s): MSE 2044
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4424 - Materials Laboratory II (1 credit)
Processing and characterization of materials; exploration of the influence of processing parameters on physical and mechanical properties. Emphasis on material synthesis.
Prerequisite(s): MSE 2044
Instructional Contact Hours: (3 Lab, 1 Crd)

MSE 4434 - Ceramic and Glass Materials Processing Laboratory (1 credit)
Introduction to experimental techniques used to synthesize, process, and analyze resulting properties of ceramic and glass materials. Measurement of property variations made possible by changing composition and processing of engineered ceramic systems.
Prerequisite(s): MSE 4414 and MSE 3314 and MSE 4424
Instructional Contact Hours: (3 Lab, 1 Crd)

MSE 4544 - Laboratory In Polymer Science (2 credits)
Experimental techniques used in the synthesis of various linear polymers, copolymers, and crosslinked networks. Determination of polymer molecular weights and molecular weight distribution. Methods used in the thermal, mechanical, and morphological characterization of polymeric systems.
Prerequisite(s): CHEM 3616 and CHEM 4534
Instructional Contact Hours: (1 Lec, 3 Lab, 2 Crd)
Course Crosslist: CHEM 4074

MSE 4554 - Polymer Engineering (3 credits)
This course is designed to introduce the student to polymers from the MSE perspective. The basics of polymer syntheses and polymerization will be outlined. The relationship between processing, structure, and properties will be presented with respect to the performance and design requirements of typical polymer applications.
Prerequisite(s): MSE 2044
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4574 - Biomaterials (3 credits)
Materials for biomedical applications. Basic material types and properties, functional uses of materials in medical applications, and tissue response mechanisms. Integrated design issues of multicomponent material design in prosthetic devices for hard and soft tissues, orthopedics , cardiovascular, and drug delivery applications.
Prerequisite(s): MSE 2034 or MSE 2044
Instructional Contact Hours: (3 Lec, 3 Crd)
Course Crosslist: BMES 4574

MSE 4584 - Biomimetic Materials (3 credits)
Introduction to structure property relationships in biological materials such as wood, bone, shells, spider silk, connective tissue, blood vessels and jellyfish. Proteins and polysaccharides, biosynthesis and assembly, biomineralization, hierarchical organization. Introduction to tissue engineering and regenerative medicine. Life cycle, environmental aspects of biofabrication.
Prerequisite(s): (MSE 2034 or MSE 2044) and (CHEM 1036 or BIOL 1106)
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4604 - Composite Materials (3 credits)
The application of the fundamental concepts of mechanics, elasticity, and plasticity to multiphase and composite materials. Constitutive equations for the mechanical and physical properties of metal, ceramic, and polymeric matrix composites. The role of processing and microstructure on properties.
Prerequisite(s): (MSE 2034 or MSE 2044) and ESM 2204
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4614 - Nanomaterials (3 credits)
Synthesis methods of 0D nanoparticles, 1D nanotubes/nanowires/nanorods, 2D nanoribbons and nanofilms, and special nano-features on supports. Bottom-up and top-down approaches. Methods of characterization for nanomaterials. Processing of nanospecies into higher order dimensions; conventional processing techniques; techniques developed solely for nanomaterials. Chemical, physical, mechanical, and electrical properties of nanomaterials and applications of nanomaterials.
Prerequisite(s): MSE 4034
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4644 - Materials Optimization Through Designed Experiments (3 credits)
Methods of analysis of variation in materials systems, manufacturing or R&D through the use of statistical methods including experimental design techniques. Instructional examples related to Materials Science and Engineering.
Prerequisite(s): MSE 3314 or MSE 4424
Instructional Contact Hours: (3 Lec, 3 Crd)

MSE 4974 - Independent Study (1-19 credits)
Instructional Contact Hours: Variable credit course

MSE 4974H - Independent Study (1-19 credits)
Instructional Contact Hours: Variable credit course

MSE 4984 - Special Study (1-19 credits)
Instructional Contact Hours: Variable credit course

MSE 4984A - Special Study (1-19 credits)
Pathway Concept Area(s): 1A Discourse Advanced
Instructional Contact Hours: Variable credit course

MSE 4994 - Undergraduate Research (1-19 credits)
Instructional Contact Hours: Variable credit course

MSE 4994H - Undergraduate Research (1-19 credits)
Instructional Contact Hours: Variable credit course

MSE 29844 - Special Study (1-19 credits)
Instructional Contact Hours: Variable credit course