MATERIALS SCIENCE AND ENGINEERING

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Curriculum in Materials Science and Engineering (http://mse.illinois.edu)

For the Degree of Bachelor of Science in Materials Science and Engineering

Materials science and engineering is the basis for all engineering. Improvements in the quality of life require knowledge of the processing and properties of current materials and the design, development and application of new materials. The Materials Science and Engineering (MatSE) curriculum provides an understanding of the underlying principles of synthesis and processing of materials and of the interrelationships between structure, properties, and processing. Students learn how to create advanced materials and systems required, e.g., for flexible electronic displays and photonics that will change communications technologies, for site specific drug delivery, for self-healing materials, for enabling the transition to a hydrogen-based economy, and for more efficient photovoltaics and nuclear systems for energy production. The curriculum uses concepts from both basic physics and chemistry and provides a detailed knowledge of what makes the materials we use every day behave as they do.

Students in the first two years take courses in general areas of science and engineering as well as courses introducing the concepts in MatSE. In the third year, students study the common, central issues related to MatSE. In the senior year, students focus on an area of MatSE of their greatest interest, providing them with the detailed knowledge to be immediately useful to corporations, become entrepreneuers, or to provide the underpinning knowledge for graduate study. Note: students interested in biomaterials take a specific set of courses to provide them with a background in biology and chemistry while maintaining a strong engineering focus.

A combined B.S.-M.S. Materials Science and Engineering degree program is available. Its admission and course requirements are described in the College of Engineering program information section (http://catalog.illinois.edu/undergraduate/engineer) and the department's website.

Focus Areas

The MatSE program provides a diverse set of courses enabling a plan of study designed around the interest of the student. The plan of study includes the core areas of materials science (ceramics, metals, polymers, electronic materials, and biomaterials), as well as emerging interdisciplinary topics (e.g., materials for energy, advanced processing and/or characterization methods, materials theory and computation). The biomaterials area requires a unique set of prerequisites and courses, and so has a distinct curriculum. Students are encouraged to take engineering, science, and business electives of interest to them and of relevance to their career goals. Highlights of the possible focus areas are:

- Advanced Processing and Characterization Methods: Introduces principles for designing and engineering materials structure, properties, and chemistry from atomic to macroscopic scales, This area also teaches fundamental and practical concepts necessary for determining materials structure and chemistry at different length scales. This area utilizes basic knowledge from physics and chemistry.
- Biomaterials: The science and engineering of materials for use in biological applications, particularly as related to human health. This area includes concepts in basic and intermediate chemistry and and basic and intermediate biology, with relatively less coverage of physics topics. It includes a subset of the standard junior year courses and requires additional chemistry and biology in the junior year.
- Composites: Studies the science and engineering of materials formed by comb8ining multiple materials into a single material. Studies of composites make significant use of properties of materials and mathematical knowledge.
- Ceramics: Studies the science and engineering of ceramic materials, including alloy design, composites, synthesis, and processing methods. Ceramics makes significant use of concepts from both basic physics and basic chemistry.
- Electronic Materials: Describes the design and engineering of materials primarily for the microelectronics industries. Topics span the ceramics, metals, and polymers areas. Concepts from basic and intermediate physics are used along with basic chemistry.
- Metals: Introduces the design and processing of metals and alloys to achieve desired properties. This area primarily uses concepts from basic and intermediate physics with relatively less emphasis on chemical concepts.
- Polymers: Teaches the methods for molecular design to achieve desired properties in individual polymers, polymer blends, and polymer composites as well as processing methods. This area primarily uses concepts from basic and intermediate chemistry with relatively less emphasis on physics concepts.
- Materials for Energy and the Environment: Studies materials for energy production, harvesting, and storage; materials for environmental remediation, water purification, and recycling; and includes discussions on sustainability and life-cycle analysis of the environmental impact of materials. Materials issues related to both renewable and non-renewable energy production are covered. This area utilizes concepts from both physics and chemistry.
- Materials Theory and Computation: Introduces computational modeling approaches for materials that span length- and time-scales from the atomic to the macroscopic. This area focuses on computational prediction of material response to different stimuli (mechanical loads, temperature, electronic excitations, etc.) and fundamental material properties.

Overview of Curricular Requirements

The curriculum requires 128 hours for graduation and is organized as follows.

Orientation and Professional Development

These courses introduce the opportunities and resources your college, department, and curriculum can offer you as you work to achieve your career goals. They also provide the skills to work effectively and successfully in the engineering profession.

ENG 100	Engineering Orientation [1]	0

MSE 183	Freshman Materials Laboratory [1,2]	1
Total Hours		1

1 *External transfer students take ENG 300 instead.*

2 *This optional course is highly recommended for freshmen and may be used to help meet free elective requirements.*

Foundational Mathematics and Science

These courses stress the basic mathematical and scientific principles upon which this engineering discipline is based.

CHEM 102	General Chemistry I	3
CHEM 103	General Chemistry Lab I	1
CHEM 104	General Chemistry II	3
CHEM 105	General Chemistry Lab II	1
MATH 221	Calculus I [1]	4
MATH 225	Introductory Matrix Theory	2
MATH 231	Calculus II	3
MATH 241	Calculus III	4
MATH 285	Intro Differential Equations	3
PHYS 211	University Physics: Mechanics	4
PHYS 212	University Physics: Elec & Mag	4
PHYS 214	Univ Physics: Quantum Physics	2
Total Hours		34

1 *MATH 220 may be substituted, with four of the five credit hours applying toward the degree. MATH 220 is appropriate for students with no background in calculus.*

Materials Science and Engineering Technical Core

These courses stress fundamental concepts and basic laboratory techniques that comprise the common intellectual understanding of materials science and engineering.

For All Students

CS 101	Intro Computing: Engrg & Sci	3
ECE 205	Elec & Electronic Circuits	3
IE 300	Analysis of Data [1]	3
or STAT 400	Statistics and Probability I	
MSE 182	Introduction to MatSE	2
MSE 201	Phases and Phase Relations	3
MSE 206	Mechanics for MatSE	4
MSE 307	Materials Laboratory I	3
MSE 308	Materials Laboratory II	3
MSE 395	Materials Design	3
MSE 401	Thermodynamics of Materials	3
MSE 402	Kinetic Processes in Materials	3
MSE 406	Thermal-Mech Behavior of Matls	3
Total Hours		36

1 *The replacement of IE 300 with STAT 400 is not allowed for students in the Biomaterials Area unless one of their area or technical electives is deemed by the Accreditation Board for Engineering and Technology (ABET) to be an engineering course. The extra hour of credit for STAT 400 may be used to help meet free elective requirements.*

For the Biomaterials Area

CHEM 232	Elementary Organic Chemistry I	0 TO 4
MCB 150	Molec & Cellular Basis of Life	4
MCB 450	Introductory Biochemistry	3
MCB 252	Cells, Tissues & Development	3
Subtotal		13
Total for the Biomaterials Area		49

For All Other Areas

MSE 304	Electronic Properties of Matls	3
MSE 405	Microstructure Determination	3
Subtotal		6
Total for all non-Biomaterials Students		42

Technical Electives

These courses stress the rigorous analysis and design principles practiced in the major subdisciplines of materials science and engineering embodied in the MatSE focus areas.

For the Biomaterials Area

Biomaterials area topical lectures selected from the list of topical lectures established by the department. [1]		5
MSE 404	Laboratory Studies in Materials Science and Engineering	3
MSE 470	Design and Use of Biomaterials	3
Topical lectures outside the biomaterials area.		6
Total Hours		17

1 *Topical Lectures* (http://www.matse.illinois.edu/academics/undergraduate/specializations.html#approved).

For All Other Areas

Topical lectures selected from the list of courses established by the department. No more than 6 hours may be from introductory topical lectures. [1]		12
MSE 404	Laboratory Studies in Materials Science and Engineering	6
Technical electives selected from the list of approved courses established by the department. [2]		6
Total Hours		24

1 *Topical Lectures* (http://www.matse.illinois.edu/academics/undergraduate/specializations.html#approved).

2 *List of approved technical electives* (http://www.matse.illinois.edu/academics/undergraduate/curriculum/technical.html).

Liberal Education

The liberal education courses (https://wiki.cites.illinois.edu/wiki/display/ugadvise/Liberal+Education+Electives) develop students' understanding of human culture and society, build skills of inquiry and critical thinking, and lay a foundation for civic engagement and lifelong learning.

Electives from the campus General Education Social and Behavioral Sciences list.	6
Electives from the campus General Education Humanities and the Arts list.	6

Electives either from a list approved by the college, or additional courses from the campus General Education lists for Social and Behavioral Sciences or Humanities and the Arts.		6
Total Hours		18

Students must also complete the campus cultural studies requirement by completing (i) one western/comparative culture(s) course and (ii) one non-western/U.S. minority culture(s) course from the General Education cultural studies lists. Most students select liberal education courses that simultaneously satisfy two or more cultural studies requirements. Courses from the western and non-western lists that fall into free electives or other categories may also be used satisfy the cultural studies requirements.

Composition

These courses teach fundamentals of expository writing.

RHET 105	Writing and Research	4
Advanced Composition (satisfied by completing the sequence MSE 307 + MSE 308 in the Materials Science and Engineering Technical Core)		
Total Hours		4

Free Electives

These unrestricted electives, subject to certain exceptions as noted at the College of Engineering Advising Website (https://wiki.cites.illinois.edu/wiki/display/ugadvise/Free+Electives?src=search), give the student the opportunity to explore any intellectual area of unique interest. This freedom plays a critical role in helping students to define research specialties or to complete minors.

Free electives. Additional unrestricted course work, subject to certain exceptions as noted at the College of Engineering advising Web site, so that there are at least 128 credit hours earned toward the degree. [1]		6

1 *College of Engineering Advising Website* (https://wiki.cites.illinois.edu/wiki/display/ugadvise/Free+Electives?src=search)

Topical Lecture Courses

The courses listed below have been approved by the department as topical lectures for all focus areas.

Biomaterials Area		
MSE 470	Design and Use of Biomaterials	3
Topical Lectures [1]		5
All Other Areas		
MSE 420	Ceramic Materials & Properties	3
MSE 421	Ceramic Processing	3
MSE 422	Electrical Ceramics	3
MSE 423	Ceramic Processing Laboratory	3
ECE 340	Semiconductor Electronics	3
MSE 460	Electronic Materials I	3
MSE 461	Electronic Materials II	3
MSE 440	Mechanical Behavior of Metals	3
MSE 441	Metals Processing	3
MSE 442	Metals Laboratory	3
MSE 443	Design of Engineering Alloys	3
MSE 450	Polymer Science & Engineering	3
MSE 452	Polymer Laboratory	3
MSE 453	Plastics Engineering	3
Area technical electives [1]		3-6

1 *Selected from the departmental list of approved area technical electives* (http://www.matse.illinois.edu/academics/undergraduate/specializations.html#approved) *for focus areas.*

Suggested Sequence

The schedule that follows is illustrative, showing the typical sequence in which courses would be taken by a student with no college course credit already earned and who intends to graduate in four years. Each individual's case may vary, but the position of required named courses is generally indicative of the order in which they should be taken. The first two years of the Suggested Sequence is the same for all MatSE students. The third and fourth years vary with the Focus Area chosen. Refer to the appropriate third and fourth year sequence.

First Year

First Semester		Hours
CHEM 102	General Chemistry I	3
CHEM 103	General Chemistry Lab I	1
ENG 100	Engineering Orientation	0
MATH 221	Calculus I	4
MSE 182	Introduction to MatSE	2
RHET 105 (or Liberal education elective)[2,3]	Writing and Research	4
	Semester Hours	14
Second Semester		
CHEM 104	General Chemistry II	3
CHEM 105	General Chemistry Lab II	1
MATH 225	Introductory Matrix Theory	2
MATH 231	Calculus II	3
MSE 183[4]	Freshman Materials Laboratory	1
PHYS 211	University Physics: Mechanics	4
RHET 105 (or Liberal education elective)[2,3]	Writing and Research	4
	Semester Hours	17

Second Year

First Semester		
CS 101	Intro Computing: Engrg Sci	3
MATH 241	Calculus III	4
MSE 201	Phases and Phase Relations	3
PHYS 212	University Physics: Elec Mag	4
Liberal education elective[3]		3
	Semester Hours	17
Second Semester		
ECE 205	Elec Electronic Circuits	3
MATH 285	Intro Differential Equations	3
MSE 206	Mechanics for MatSE	4

PHYS 214	Univ Physics: Quantum Physics	2
Liberal education elective[3]		3
	Semester Hours	15
	Total Hours:	63

All students except Biomaterials Area

Third Year

First Semester		Hours
IE 300 or STAT 400[5]	Analysis of Data	3
MSE 307[6]	Materials Laboratory I	3
MSE 401	Thermodynamics of Materials	3
MSE 406	Thermal-Mech Behavior of Matls	3
Liberal education elective[3]		3
	Semester Hours	15
Second Semester		
MSE 304	Electronic Properties of Matls	3
MSE 308[6]	Materials Laboratory II	3
MSE 402	Kinetic Processes in Materials	3
MSE 405	Microstructure Determination	3
Topical Lecture (Intro Level Suggested)		3
Liberal education elective[1]		3
	Semester Hours	18

Fourth Year

First Semester		
Topical lecture courses[7,8]		6
MSE 404	Laboratory Studies in Materials Science and Engineering	3
Technical elective[9]		3
Liberal education elective[3]		3
Free elective		3
	Semester Hours	18
Second Semester		
MSE 395	Materials Design	3
MSE 404	Laboratory Studies in Materials Science and Engineering	3
Topical Lecture		3
Technical elective[9]		3
Free elective		3
	Semester Hours	15
	Total Hours:	66

Biomaterials Area

Third Year

First Semester		Hours
CHEM 232	Elementary Organic Chemistry I	3
MSE 307[6]	Materials Laboratory I	3
MSE 401	Thermodynamics of Materials	3
MSE 406	Thermal-Mech Behavior of Matls	3
MCB 150	Molec Cellular Basis of Life	4
	Semester Hours	16
Second Semester		
MCB 252	Cells, Tissues Development	3
IE 300 or STAT 400[5]	Analysis of Data	3
MSE 308[6]	Materials Laboratory II	3
MSE 402	Kinetic Processes in Materials	3
Liberal education elective[3]		3
	Semester Hours	15

Fourth Year

First Semester		
MSE 470	Design and Use of Biomaterials	3
MCB 450	Introductory Biochemistry	3
Topical lecture in biomaterials area		2
Topical lecture outside of biomaterials area		3
Liberal education elective[3]		3
Free Elective		3
	Semester Hours	17
Second Semester		
MSE 395	Materials Design	3
MSE 404	Laboratory Studies in Materials Science and Engineering	1.5
Topical lecture in biomaterials area		3
Topical lecture outside of biomaterials area		3
Liberal education elective[3]		3
Free elective		3
	Semester Hours	16.5
	Total Hours:	64.5

1 *MATH 220 may be substituted, with four of the five credit hours applying toward the degree. MATH 220 is appropriate for students with no background in calculus.*

2 *RHET 105 may be taken in the first or second semester as authorized. The alternative is a social sciences or humanities elective.*

3 *Liberal education electives* (https://wiki.cites.illinois.edu/wiki/display/ugadvise/Liberal+Education+Electives) *must include 6 hours of social & behavioral sciences and 6 hours of humanities & the arts course work from the campus General Education lists. The remaining 6 hours may be selected from a list maintained by the college, or additional course work from the campus General Education lists for social & behavioral sciences or humanities & the arts. Students must also complete the campus cultural studies requirement by completing (i) one western/comparative culture(s) course and (ii) one non-western/U.S. minority culture(s) course from the General Education cultural studies lists. Most students select liberal education courses that simultaneously satisfy these cultural studies requirements. Courses from the western and non-western lists that fall into free electives or other categories may also be used satisfy the cultural studies requirements.*

4 *This course is highly recommended for freshmen, who may use it to help meet free elective requirements.*

5 *Satisfies the General Education Advanced Composition requirement.*

6 *The replacement of IE 300 with STAT 400 is not allowed for students in the Biomaterials Area unless one of their area or technical electives is deemed by ABET to be an engineering course. The extra hour of credit for this course may be used to help meet free elective requirements.*

[7] *To be selected from list of area specialty course* (http://www.matse.illinois.edu/academics/undergraduate/specializations.html#approved) *established by the department to provide an acceptable level of study in the student's chosen focus area.*

[8] *During fourth year, strongly recommended is incorporation of one or more of an internship, co-op position, and a research project during summers or an academic semester, or both. For students who intend to continue in graduate school, recommended additionally is the undertaking of a research project (Senior Thesis) in the senior year. The project may take the place of 4-6 hours of free, technical, or area specialty electives.*

[9] *Selected from the departmental list of approved technical electives* (http://www.matse.illinois.edu/academics/undergraduate/curriculum/technical.html).

MSE Class Schedule (https://courses.illinois.edu/schedule/DEFAULT/DEFAULT/MSE)

Courses

MSE 101 Materials in Today's World credit: 3 Hours.
Introduction to the field of materials science. Examination and demonstration of materials and their properties in the context of their use in everyday objects. Survey of the role materials have played and will continue to play in shaping society. Intended for non-engineering majors. Technical elective credit is not given to College of Engineering majors.
This course satisfies the General Education Criteria for:
Nat Sci Tech - Phys Sciences

MSE 182 Introduction to MatSE credit: 2 Hours.
Overview of MatSE as a basis for understanding how structure, property, and processing relationships are developed and used for different types of materials. Case studies of advances in new materials and processes illustrating the role of materials in modern society. Laboratory-discussion demonstrations and experiments. Design-team analysis or synthesis of objects that use materials creatively.

MSE 183 Freshman Materials Laboratory credit: 1 Hour.
Team-based laboratory developing concepts introduced in MSE 182. Practical descriptions of materials concepts, literature research, experimental design, concept validation, teamwork, and presentation of results. Prerequisite: MSE 182.

MSE 199 Undergraduate Open Seminar credit: 1 to 5 Hours.
May be repeated to a maximum of 5 hours. May be repeated in the same term.

MSE 201 Phases and Phase Relations credit: 3 Hours.
Understanding microstructure. Quantitative examination of phases (crystalline and non-crystalline structures) and the relationships between phases (phase diagrams). Commercial practices for producing desired microscopic phase configurations and macroscopic shapes (processing). Credit is not given for both MSE 201 and MSE 280. Prerequisite: MSE 182; credit or concurrent enrollment in CHEM 104, MATH 231 and PHYS 211.

MSE 206 Mechanics for MatSE credit: 4 Hours.
Statics, mechanics of materials, and fluid mechanics concepts pertinent to the fields of materials science and engineering: force resultants; stresses and strains produced in elastic bodies; microscopic effects of different loading states (tension, compression, torsion, and bending) on deformable bodies; beam stresses and deflections; three-dimensional stresses and strains; stress and strain-rate relationships for Newtonian and non-Newtonian fluids; conservation equations (control volume analysis) for fluid flow; Reynolds number; slow inertial and turbulent flows. Credit is not given for both MSE 206 and either TAM 251 or TAM 335. Prerequisite: MATH 225, MATH 241 and PHYS 211; credit or concurrent enrollment in CS 101 and MSE 201.

MSE 280 Engineering Materials credit: 3 Hours.
Materials science and engineering of ceramics, electronic materials, metals and polymers. Bonding; crystallography; imperfections; processing and properties of semiconductors, polymers, metals, ceramics and composites; phase diagrams. Case studies. Credit is not given for both MSE 280 and any of CEE 300, ME 330, MSE 201. Prerequisite: CHEM 102 and PHYS 211.

MSE 304 Electronic Properties of Matls credit: 3 Hours.
Electronic structure and bonding of materials, electrical conduction in metals and semiconductors, and dielectric and magnetic properties of solids. Credit is not given for both MSE 304 and PHYS 460. Prerequisite: PHYS 214.

MSE 307 Materials Laboratory I credit: 3 Hours.
Experiments using optical and scanning electron microscopy and various thermal and thermodynamic measuring techniques. Familiarization with laboratory test instruments. MSE 307 and MSE 308 are approved for General Education credit only as a sequence. Both courses must be completed to receive Advanced Composition credit. Prerequisite: Credit or concurrent registration in MSE 401 and either MSE 201 or MSE 280.
This course satisfies the General Education Criteria for:
Advanced Composition

MSE 308 Materials Laboratory II credit: 3 Hours.
Experiments characterizing mechanical, transport, and magnetic-electric properties of materials and the use optical and scanning electron microscopy and infrared spectroscopy. MSE 307 and MSE 308 are approved for General Education credit only as a sequence. Both courses must be completed to receive Advanced Composition credit. Prerequisite: MSE 307; credit or concurrent registration in MSE 304 and MSE 405.
This course satisfies the General Education Criteria for:
Advanced Composition

MSE 395 Materials Design credit: 3 Hours.
Design of various engineering devices, objects, or systems. Team-based and faculty-guided projects directed toward the development of materials-based solutions to problems originating from student, faculty, and industrial suggestions. Solutions are based on the knowledge, skills, and design experience acquired in earlier course work and incorporate engineering standards and realistic constraints such as economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political concerns. Prerequisite: This course is available to engineering majors with senior standing only.

MSE 396 Introduction to Research credit: 1 to 3 Hours.
Fundamental tenets of research including an introduction to laboratory safety, constructing a hypothesis, and the design of experiments to test the hypothesis. Basics of mathematical modeling and statistical analysis of data, including the analysis of research data. Emphasis on exposure to the basic procedures comprising engineering communication and the importance of verbal and written communication. Approved for Letter and S/U grading. May be repeated in separate terms.

MSE 397 Independent Study credit: 1 to 4 Hours.
Individual study of any topic in materials science and engineering selected by the student and conducted under the supervision of a member of the faculty. May be repeated to a maximum of 4 hours. Prerequisite: Consent of instructor.

MSE 398 Special Topics credit: 1 to 4 Hours.
Subject offerings of new and developing areas of knowledge in materials science and engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. May be repeated in the same or separate terms if topics vary.

MSE 401 Thermodynamics of Materials credit: 3 Hours.
Basic thermodynamic principles including energy, entropy, and free energy; macroscopic properties of hard and soft materials systems, such as equilibrium states, phases, and phase transitions. Application of phase diagrams. Statistical interpretation of thermodynamics on the atomistic level. 3 undergraduate hours. 3 graduate hours. Credit is not given for both MSE 401 and CHEM 444 or PHYS 427. Prerequisite: MSE 201 or MSE 280; credit or concurrent registration in MATH 285.

MSE 402 Kinetic Processes in Materials credit: 3 Hours.
Kinetics of chemical reactions; rate equations, reaction mechanisms; transport processes; diffusion equations, atomic and molecular diffusion; phase transformations; nucleation, crystallization, displacive, spinodal decomposition; surface and interface phenomena; sintering, grain growth, recovery, and recystallization. 3 undergraduate hours. 3 graduate hours. Prerequisite: MSE 201 and MSE 401.

MSE 403 Synthesis of Materials credit: 3 Hours.
Fundamentals of the synthesis of materials. Principles of synthesis; processes, approaches, synthetic methodology and probes; methodologies in materials synthesis; polymerization, sol-gel processes, liquid and vapor phase synthesis, materials coupling reactions, and precursor-derived, radiation-induced and asymmetric synthesis. 3 undergraduate hours. 3 graduate hours. Prerequisite: MSE 201; credit or concurrent registration in MSE 401.

MSE 404 Laboratory Studies in Materials Science and Engineering credit: 1.5 Hours.
Experiments include direct hands-on investigations or are performed through computational approaches. Laboratory experiences include both fundamental studies as well as investigations on more applied topics. 1.5 undergraduate hours. 1.5 graduate hours. May be repeated if topics vary. Prerequisite: MSE 307 and MSE 308 or permission of instructor. Senior standing.

MSE 405 Microstructure Determination credit: 3 Hours.
Fundamentals and applications of various forms of microscopy and diffraction for characterization of physical microstructure of materials and of various forms of spectroscopy for characterization of chemical microstructure. 3 undergraduate hours. 3 graduate hours. Prerequisite: PHYS 214, CHEM 104, MSE 201, and MSE 307.

MSE 406 Thermal-Mech Behavior of Matls credit: 3 Hours.
Fundamentals of elastic, viscoelastic and plastic deformation of materials, elementary theory of statics and dynamics of dislocations; strengthening mechanisms; behavior of composites; fracture and fatigue behavior; fundamentals of thermal behavior: heat capacity, thermal expansion and conductivity; effects of thermal stress. 3 undergraduate hours. 3 graduate hours. Credit is not given for both MSE 406 and either ME 430 or TAM 424. Prerequisite: MSE 206; credit or concurrent registration in MSE 401.

MSE 420 Ceramic Materials & Properties credit: 3 Hours.
Ceramic material fundamentals, emphasizing structure-property relations. Development, use, and control of the properties of a wide variety of ceramic materials from a physico-chemical point of view. 3 undergraduate hours. 3 graduate hours.

MSE 421 Ceramic Processing credit: 3 or 4 Hours.
Microstructure development and processing of ceramic materials, with an emphasis on structure-property-processing relationships. Processing methodologies and their effects on microstructural development. Illustration and examination of several ceramic components within this context. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: MSE 420.

MSE 422 Electrical Ceramics credit: 3 Hours.
Electrical ceramics, from insulators to conductors, and magnetic and optical materials; the role of the processing cycle and microstructure development on the design and performance of electrical components; capacitors, resistors, and inductors; structure-property relations for pyro-, piezo-, and ferroelectric materials; perovskite and spinel based structures; varistors, thermistors, transducers, actuators, memory elements, multilayered components, and their applications. Design project. 3 undergraduate hours. 3 graduate hours. Prerequisite: MSE 420.

MSE 423 Ceramic Processing Laboratory credit: 3 Hours.
Experiments and demonstrations involving a wide range of modern ceramic processing methods will be conducted to develop fundamental understanding of the relationships between raw materials, processing methods, microstructural development, and physical properties. Lab emphasis on the underlying physics and chemistry of processing and design of processing routes to achieve desired material properties. Technical reports. 3 undergraduate hours. 3 graduate hours. Prerequisite: MSE 421.

MSE 440 Mechanical Behavior of Metals credit: 3 Hours.
Mechanical behavior of solids: crystal plasticity, dislocations, point defects and grain boundaries, creep and fatigue behavior, and fracture. 3 undergraduate hours. 3 graduate hours. Prerequisite: MSE 406.

MSE 441 Metals Processing credit: 3 Hours.
Melt, mechanical, thermal, powder, and surface processing of metals. Extraction of metals, joining of metals, metal composites, and metal recycling. Relationships between the processing of metals, the microstructures that are produced, and the behavior of metal components. 3 undergraduate hours. 3 graduate hours. Prerequisite: MSE 406.

MSE 442 Metals Laboratory credit: 3 Hours.
Advanced metallurgy laboratory. Effects of heat treatment; mechanical testing; oxidation and corrosion; metallography of selected alloys. 3 undergraduate hours. 3 graduate hours. Prerequisite: MSE 308, MSE 440, and MSE 441.

MSE 443 Design of Engineering Alloys credit: 3 Hours.
Application of science and engineering principles to the design, selection, and performance of engineering alloys. Alloy classes, design, effect of alloying elements, relation to processing variables, and structure-property relationships; design project. 3 undergraduate hours. 3 graduate hours. Prerequisite: MSE 401 and MSE 402.

MSE 445 Corrosion of Metals credit: 3 or 4 Hours.
Electrochemistry, thermodynamics, and kinetics of corrosion; behavior of ferrous and nonferrous metals; corrosion rates; corrosion control; cathodic and anodic protection; high-temperature corrosion; corrosion testing; electrolytic machining methods. 3 undergraduate hours. 3 or 4 graduate hours.

MSE 450 Polymer Science & Engineering credit: 3 or 4 Hours.
Polymer solution properties, conformation, and molecular weight characterization. Rheological and viscoelastic behavior: relaxations and transitions, rubber elasticity. Crystallinity, morphology, and deformation of crystalline polymers. Blends and composites. Methods of fabrication. 3 undergraduate hours. 3 or 4 graduate hours.

MSE 452 Polymer Laboratory credit: 3 Hours.
Experimental investigations of polymer synthesis, characterization (molecular, thermal, structural and electronic), processing and device fabrication. 3 undergraduate hours. 3 graduate hours. Prerequisite: MSE 450.

MSE 453 Plastics Engineering credit: 3 Hours.
Engineering characteristics of plastics; viscoelasticity, viscosity, yield, and fracture; reinforced polymers; processing; environmental considerations; applicability of technical data sheets; design (project); current advances. 3 undergraduate hours. 3 graduate hours. Prerequisite: MSE 450.

MSE 454 Mechanics of Polymers credit: 3 Hours.
Same as AE 427 and TAM 427. See TAM 427.

MSE 455 Macromolecular Solids credit: 3 Hours.
Mechanical behavior of amorphous and semi-crystalline polymers; overview of polymer structure and characterization; polymer morphology; orientation effects, rubber elasticity, polymer linear viscoelasticity using Boltzmann superposition and mechanical models; measurement of viscoelastic properties; relaxation and transitions; polymeric yield phenomena and plastic flow; deformation mechanisms; fracture and craze formation; impact and fatigue. 3 undergraduate hours. 3 graduate hours. Prerequisite: MSE 450.

MSE 456 Mechanics of Composites credit: 3 Hours.
Behavior of composite materials and their use in engineering structures: behavior and properties of the constituent fibers and matrices, micromechanical predictions of composite properties, anisotropic elasticity, behavior of composite laminae, and classical lamination theory; fracture mechanisms, failure theories; behavior of composite plates and beams. Same as AE 428 and TAM 428. 3 undergraduate hours. 3 graduate hours. Prerequisite: AE 321, CEE 300, ME 330, or MSE 406.

MSE 457 Polymer Chemistry credit: 3 or 4 Hours.
Methods used to make polymers including reaction mechanisms, kinetics, and analytical techniques. Emphasis on understanding how macromolecule structure, composition, and properties are controlled through a variety of synthetic approaches. Same as CHEM 480. 3 undergraduate hours. 3 or 4 graduate hours.

MSE 458 Polymer Physics credit: 3 or 4 Hours.
Physics of polymer systems. Equilibrium conformation, structure, properties and phase transitions of polymer solutions, dense melts, liquid crystals, mixtures, block copolymers, surfaces and interfaces, gels and rubbers, biopolymers, and electronic polymers. Same as CHEM 482. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: MSE 401.

MSE 460 Electronic Materials I credit: 3 Hours.
Materials science, engineering, and processing of semiconductors. Semiconductor structure and chemistry relationships to electronic and optical properties. Control of processing to achieve desired properties; design and production of novel materials. 3 undergraduate hours. 3 graduate hours. Prerequisite: ECE 340; MSE 304 or PHYS 460.

MSE 461 Electronic Materials II credit: 3 Hours.
Materials science, engineering, and processing of microlithographic materials, conductors, and dielectrics for electronic applications. Performance related to materials properties and processing. Processing commonly used in microelectronic circuit manufacture for metallization, dielectric formation, and lithography. 3 undergraduate hours. 3 graduate hours. Prerequisite: ECE 340.

MSE 462 Electronic Materials Lab credit: 3 Hours.
Fabrication, analysis, and properties of thin film materials. Principles and practice of (i) deposition of thin film materials by vacuum evaporation, sputtering and plasma assisted processes; (ii) modification of properties by thermal reaction, surface treatment, etc.; (iii) characterization of key properties including electrical conductivity, optical properties, and stress. Methods to optimize the film microstructure and engineering properties via growth techniques. 3 undergraduate hours. 3 graduate hours. Prerequisite: ECE 340.

MSE 466 Materials in Electrochem Syst credit: 3 Hours.
Materials issues in electrochemical systems including fundamental thermodynamics, kinetics and electrode processes in electrochemical systems and materials specific issues in the materials design, materials in energy storage and conversion systems, and electrochemical corrosion. Emphasis placed on issues of materials selection, microstructure, systems design, materials limitations, and data analysis. 3 undergraduate hours. 3 graduate hours. Credit is not given for both MSE 466 and CHEM 524.

MSE 470 Design and Use of Biomaterials credit: 3 Hours.
Characterization and use of biomaterials in medical applications. Concepts of biocompatibility in terms of structure and properties of materials and interactions between materials and proteins, cells, and tissue. Issues related to the design of biomaterials. Design of biomaterials to meet specific medical needs. 3 undergraduate hours. 3 graduate hours. Prerequisite: Credit or concurrent registration in both MCB 252 and either CHEM 232 or MSE 403.

MSE 472 Biomaterials Laboratory credit: 3 Hours.
Experiments involving the chemistry and physics of biomaterials, biocompatibility of materials, tissue regeneration, rheology of biomaterials and tissues, structural studies of biomaterials, and controlled release of small molecules and drugs. Laboratory techniques for protein purification, cytotoxicity testing, tissue culture, mechanical testing, microscopy, and X-ray diffraction. Same as BIOE 473. 3 undergraduate hours. 3 graduate hours. Prerequisite: MSE 470.

MSE 473 Biomolecular Materials Science credit: 3 Hours.
Fundamental and unifying principles in biomolecular materials science. Nucleic acids, proteins, lipids, and sugars. Specific and non-specific interactions which govern biomolecular behavior in a wide range of contexts (e.g., self-assembly, cell adhesion). Present knowledge and empirical evidence integrated with discussions of experimental characterization and manipulation techniques in biotechnology. Application of course content and expository research into current literature via a case study term project. 3 undergraduate hours. 3 graduate hours.

MSE 474 Biomaterials and Nanomedicine credit: 3 Hours.
Design and synthesis of polymeric biomaterials and nanobiomaterials for their applications in drug and gene delivery. Part (1) fundamental biopolymer synthesis: functional group protection and de-protection; bioconjugation; protein pegylation and design and synthesis of natural and synthetic non-degradable and degradable polymers, hydrogels, bio-inspired materials, and stimuli responsive biomaterials. Part (2) preparation of nanomedicines for drug and gene delivery: nanofabritation of micelles, nanoparticles, protein conjugates, drug conjugates, nanoencapsulates, and polymeric vesicles; in-vitro and in-vivo small-molecule, gene, and protein delivery. Impact of the chemical structures of biopolymers on the stability, biocompatibility, toxicity, and in-vitro and in-vivo efficacy; clinical translation of the resulting nanomedicines in drug delivery. 3 undergraduate hours. 3 graduate hours. Prerequisite: CHEM 236 or MSE 457; MCB 450.

MSE 480 Surfaces and Colloids credit: 3 or 4 Hours.
Chemistry and physics of surfaces and interfaces, with emphasis on behavior in liquid media. Surface composition; surface and interfacial forces; colloidal stability and flocculation; amphiphilic molecules. Same as CHEM 488. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: MSE 401.

MSE 481 Electron Microscopy credit: 3 or 4 Hours.
Theory and application of transmission electron microscopy and diffraction with emphasis on thin crystals; electron optics, interference phenomena, interpretation of images and diffraction patterns, specimen preparation. 3 undergraduate hours. 4 graduate hours. Prerequisite: MSE 405.

MSE 484 Composite Materials credit: 3 or 4 Hours.
Metal, ceramic, and polymer matrix composites. Interrelationships between processing, microstructure, and properties. Selecting composite materials for different engineering applications. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: MSE 201 and MSE 206.

MSE 485 Atomic Scale Simulations credit: 3 or 4 Hours.
Application of Monte Carlo and Molecular Dynamics techniques in primarily classical simulations to understand and predict properties of microscopic systems in materials science, physics, biology, and chemistry. Numerical algorithms, connections between simulation results and real properties of materials (structural or thermodynamic), and statistical and systematic error estimation using real simulation programs. Simulation project comprised of scientific research, algorithm development, and presentation. Same as CSE 485 and PHYS 466. 3 undergraduate hours. 4 graduate hours. Prerequisite: MSE 401; one of C, C++, or Fortran programming experience.

MSE 487 Materials for Nanotechnology credit: 3 or 4 Hours.
Survey of the synthesis, processing, structure properties and technological applications of materials with nanometer dimensions. Semiconductor nanocrystals and size-dependent optical properties; metal nanostructures and plasmonics; nanowires and nanotubes; electronics and optoelectronics; nanoscale heterostructures; assembly and fabrication. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: MSE 401 and PHYS 214.

MSE 488 Optical Materials credit: 3 or 4 Hours.
Optical properties of materials of current and potential technological importance and application to devices. Applicable optics fundamentals based on Maxwell's equations. Liquid crystals for displays; photopolymers for holographic data storage; electro-optic materials for high speed light modulators; electroluminescent materials for light emitting diodes. Application of optics, materials and chemistry in design of practical devices. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: MATH 285 and PHYS 214.

MSE 489 Matl Select for Sustainability credit: 3 or 4 Hours.
Quantitative methods to optimize the selection of materials including traditional (minimize mass or volume, maximize performance) and sustainability (minimize energy consumption and CO2 emission during synthesis, maximize recyclability) goals. Tradeoff methods to optimize both via engineering design and materials selection for product lifetime, economic outlay and return, time dynamics and materials consumption, recycling, and disposal. Application of commercial software to optimize selections. For engineering and science majors only. 3 undergraduate hours. 4 graduate hours.

MSE 492 Lab Safety Fundamentals credit: 1 Hour.
Key aspects of laboratory setups, operating procedures, and emergency preparedness measures necessary for the experimentalist. Same as CHEM 494. 1 undergraduate hour. 1 graduate hour. Approved for S/U grading only.

MSE 497 Independent Study credit: 1 to 4 Hours.
Individual study of any topic in materials science and engineering under the supervision of a member of the faculty. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated to a maximum of 4 hours. Prerequisite: Consent of instructor.

MSE 498 Special Topics credit: 1 to 4 Hours.
Subject offerings of new and developing areas of knowledge in materials science and engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated in the same or separate terms if topics vary.

MSE 499 Senior Thesis credit: 1 to 5 Hours.
Individual research in an area of materials science and engineering under the supervision of members of the staff. 1 to 5 undergraduate hours. No graduate credit. May be repeated to a maximum of 6 hours. Prerequisite: Grade point average of 3.0 and consent of instructor.