MATERIALS SCIENCE AND NANOENGINEERING

Contact Information

Materials Science and NanoEngineering
https://msne.rice.edu/
410 O'Connor Building for Engineering and Science
713-348-3698

Karen Lozano
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Materials science and engineering is about the processing, structure, properties, and performance of materials, such as metals and their alloys, semiconductors, ceramics, glass, polymers, composites, biomaterials, and nanomaterials. Materials scientists and engineers apply principles of math, physics and chemistry to design, produce, characterize, and utilize materials in all hardware that are essential to modern society. Examples range in size and properties from the nanometer-thick atomic layers in CPU transistors for data center and smart phones, the single-crystal superalloy blades in turbine engines, to the coated steels used in transcontinental pipelines and power lines. The Materials Science and NanoEngineering (MSNE) curriculum provides students with the requisite skills and educational background to contribute to the solution of many materials and nanoengineering problems, allows graduates to work in a fascinating field, and makes it possible to become a leader in one of the most challenging areas of technology.

The MSNE department's graduate degree programs include a non-thesis professional master's degree as well as research degrees which include a thesis. These programs, in their comprehensive educational and research activities, collaborate with other departments at Rice and other institutions and industry in Houston, including those in the Texas Medical Center. Collaborations are also extended to universities in the United States, Europe, Asia, North and South America. International collaborations include joint research activities as well as faculty and student visitor exchanges.

Graduate studies in the department may lead to specialization in one of several areas, including Advanced Manufacturing, Biomaterials, Carbon Nanomaterial Composites, Computational Materials Science, Material Modeling and Theories, Electron Microscopy and in situ Methods, Energy Conversion and Storage, Low Dimensional Materials, Mechanical Properties and Nanomechanics, Nanotechnology, Optical Materials, Photonics and Nanoplasmonics, Quantum and Electronic Materials, Surfaces and Interfaces, Thin Films and Coatings, and Ultralight-Weight Ultrahigh-Strength Multifunctional Materials. For details about these faculty research areas, please go to the MSNE website (https://msne.rice.edu/).

Bachelor's Programs

- Bachelor of Arts (BA) Degree with a Major in Materials Science and NanoEngineering (https://ga.rice.edu/programs-study/departments-programs/engineering/materials-science-nanoengineering/materials-science-nanoengineering-ba/)
- Bachelor of Science in Materials Science and NanoEngineering (BSMSNE) Degree (https://ga.rice.edu/programs-study/departments-programs/engineering/materials-science-nanoengineering/materials-science-nanoengineering-bsmsne/)

Master's Programs

- Master of Materials Science and NanoEngineering (MMSNE) Degree (https://ga.rice.edu/programs-study/departments-programs/engineering/materials-science-nanoengineering/materials-science-nanoengineering-mmsne/)
- Master of Science (MS) Degree in the field of Materials Science and NanoEngineering (https://ga.rice.edu/programs-study/departments-programs/engineering/materials-science-nanoengineering/materials-science-nanoengineering-ms/)

Doctoral Program

- Doctor of Philosophy (PhD) Degree in the field of Materials Science and NanoEngineering (https://ga.rice.edu/programs-study/departments-programs/engineering/materials-science-nanoengineering/materials-science-nanoengineering-phd/)

Department Chair

Karen Lozano

Associate Chair for Graduate Students

Ming Tang

Associate Chair for Undergraduate Students

Hanyu Zhu

Professors

Pulickel M. Ajayan
Enrique V. Barrera
Geoffroy Hautier
Jun Lou
Karen Lozano
Lane Martin
Boris I. Yakobson

Associate Professors

Xuedan Ma
Ming Tang
Hanyu Zhu

Assistant Professors

Yimo Han
Scott Keene
HaeYeon Lee
Guilherme Migliato Marega
Harris Pirie
Christina Tringides

Research Professor

Robert Vajtai

Associate Research Professor

Evgeni Penev

Assistant Research Professor

Xiang Zhang

Professor in the Practice

Ricardo Zednik

Lecturers

Randy John
Valery N. Khabashesku

Joint Appointments

Pedro J.J. Alvarez
Gang Bao
Sibani Lisa Biswal
Bezawit Getachew
Naomi J. Halas
Shengxi Huang
Matthew Jones
Junichiro Kono
Qilin Li
Angel A. Martí-Arbona
Antonios G. Mikos
Aditya D. Mohite
Satish Nagarajaiah
Douglas Natelson
Lea Nienhaus
Peter Nordlander
Matteo Pasquali
Vanessa Sanchez
Gustavo E. Scuseria
Pol D. Spanos
James M. Tour
Rafael Verduzco
Haotian Wang
R. Bruce Weisman
Michael S. Wong

Adjunct Professors

Ghanashyam Acharya
Sivaram Arepalli
Jaime Bonilla-Rios
Alan Dalton
Baburaj Eranezhuth
Francisco Robles Hernandez
Alberto Pimpinelli
Muhammad Maksud Rahman
Ramamoorthy Ramesh
Ajit Roy
Soumyabrata Roy
Venkataraman Swaminathan
Edwin L. Thomas
Vinod Veedu
Nikhil Verghese
Zhao Wang
Yufeng Zhao

For Rice University degree-granting programs:
To view the list of official course offerings, please see Rice's Course Catalog (https://courses.rice.edu/admweb/!SWKSCAT.cat?p_action=cata).
To view the most recent semester's course schedule, please see Rice's Course Schedule (https://courses.rice.edu/admweb/!SWKSCAT.cat).

Materials Science and NanoEngineering (MSNE)

MSNE 201 - DISCOVERING MATERIALS SCIENCE AND ENGINEERING: ENGINEERING SOLUTIONS FOR A CHANGING WORLD
Short Title: MATERIALS FOR THE FUTURE
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Introduction to the properties of materials and their applications to address global opportunities in engineering, technology, chemistry, energy, and medicine. Discovery of the role of materials in solving historical and future challenges. Discussion of materials science and nanoengineering as a foundational building block of our civilization. General discussion of nanotechnology, from multidisciplinary research to consumer products. Includes hands-on demonstrations, student-lead projects, and lab tours. Freshmen are encouraged to enroll. Open to ALL majors. Required for MSNE majors.

MSNE 203 - DATA SCIENCE, MACHINE LEARNING AND AI APPLIED TO MATERIALS SCIENCE
Short Title: AI FOR MATERIALS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Many technologies will not be possible without the understanding and control of matter. Airplanes need to be built with advanced high strength yet lightweight aluminum alloys and your cell phone will not run without the complex transition metal oxides used in the battery. The field focusing on the development and discovery of new Materials: Materials Science has seen a growing use of machine learning and artificial intelligence (AI) approaches. This class will provide an introduction to data-driven approaches in physical science and engineering within the context of materials science. The class will introduce common machine learning and AI approaches (e.g., linear regression, decision trees, neural networks, …) providing general guidelines for their proper use as well as materials science use cases. The class will in parallel introduce important concepts and data sets in materials science as well basic notions of coding in python. Recommended Prerequisite(s): MATH 101/105, Phys 101/111, Chem 121/111

MSNE 210 - WILD TOPICS IN CHEMISTRY AND NANOTECHNOLOGY
Short Title: WILD TOPICS CHEM AND NANOTECH
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hour: 1
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: A variety of topics related to chemistry and nanotechnology will be discussed. Some topics are classical while others are current. Topics may include nanocars, molecular electronics, how to form a start-up company. Grades will be based upon attendance and quizzes. Cross-list: CEVE 210, CHEM 210. Repeatable for Credit.

MSNE 211 - INTRODUCTION TO MATERIALS SCIENCE FOR ENGINEERS
Short Title: INTR MAT SCI FOR ENGINEERS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Freshman level introduction to the science of solid materials. Includes metals, ceramics, plastics, and semiconductors, as well as the properties of solid materials from atomic and macroscopic points of view. Required for materials science and engineering majors. NOTE: Freshman are encouraged to register for this course.

MSNE 222 - MATERIALS IN NATURE AND BIOMIMETIC STRATEGIES
Short Title: BIOMIMETIC MATERIALS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: This course will discuss the origin of several materials that exist in nature from a technology perspective and strategies to replicate them using synthetic materials processing protocols. Silicates, carbon-based materials, abalone shells, bone, etc. will be used to discuss the fascinating architecture developed by nature. Similarly, several functional structures designed by nature such as Gecko tape and IR sensors will be discussed for designing bio-medic structures and devices. NOTE: Not offered every year. Graduate/Undergraduate Equivalency: MSNE 555.

MSNE 238 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Internship/Practicum, Laboratory, Lecture, Seminar, Independent Study
Credit Hours: 1-4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Topics and credit hours may vary each semester. Contact department for current semester's topic(s). Repeatable for Credit.

MSNE 302 - MATERIALS PROCESSING AND NANOMANUFACTURING
Short Title: MATERIALS PROCESSING
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 101 and CHEM 121 and PHYS 101
Description: The course will discuss diverse materials forming processes, including applications for metals, ceramics and polymers. Forming processes from very large to nano scale will be discussed. Emphasis will be understanding how forming processes affect materials properties and how processes are selected based upon the materials and sizes of components being manufactured. Course content will be useful for diverse engineering majors and will be appropriate for sophomores - seniors.

MSNE 304 - MATERIALS SCIENCE JUNIOR LAB
Short Title: MATERIALS SCIENCE JUNIOR LAB
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MSNE 211 or MSNE 301
Description: Through this course, you will be able to independently operate various types of common materials testing and metallography equipment. The labs provide a path of self-discovery about the depth of your knowledge and your intuitive insight into the quality of experimental data. You will learn, acquire and demonstrate Materials Laboratory fundamentals. Required for materials science and engineering majors. To obtain registration permission, please email your MSNE degree plan to the instructor at the beginning of the Fall Registration period. The lab time will be decided through voting by the end of the Fall registration period. Instructor Permission Required. Mutually Exclusive: Cannot register for MSNE 304 if student has credit for MSNE 303.

MSNE 311 - MATERIALS SELECTION AND DESIGN
Short Title: MATERIALS SELECTION & DESIGN
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to students with a major in Materials Science & NanoEng. Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (MSNE 211 or MSNE 301) and MSNE 304
Description: Diverse types of commercially available materials are considered for applications of current economic importance based on their various useful properties. Student learning is primarily through a hands-on team project and deconstruction of commercial products as well as individual oral presentations. Instructor Permission Required.

MSNE 366 - INTRODUCTION TO MATERIALS IN THE ENERGY TRANSITION
Short Title: MATERIALS ENERGY TRANSITION
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Climate change and energy transition are two defining issues of our society. This course provides students with an overview of the complex interaction between energy, economics, politics, technology and society that determine the energy transition, with a special focus on materials needs to sustain this transition. The course uses a TECOP framework, that utilizes technology, economics, commercial, organizational and political/societal lenses to obtain a nuanced perspective of the energy transition. Cross-list: CHBE 366. Recommended Prerequisite(s): This course is open to Junior and Senior students enrolled in any of the disciplines in the School of Engineering and the School of Natural Sciences. An understanding of thermodynamics and basic chemistry are recommended.

MSNE 389 - ETHICS & SAFETY FOR MATERIALS ENGINEERS
Short Title: ETHICS & SAFETY FOR MATER ENG
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hour: 1
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Moral duty as well as legal and contractual obligations related to the practice of materials engineering. Issues of importance include safety, conflicts of interest, noncompetition & nondisclosure agreements, as well as confidential and proprietary information. Several examples of ethical lapses and various fraudulent activities will be reviewed, as well as “special processes” which pose the greatest risk for ethics violations. Graduate/Undergraduate Equivalency: MSNE 589.

MSNE 401 - THERMODYNAMICS IN MATERIALS SCIENCE
Short Title: THERMODYNAMICS IN MAT SCIENCE
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (CHEM 112 or CHEM 122) and MATH 212
Description: Unified presentation of the kinetics and thermodynamics of mass and energy transport. Includes heterogeneous equilibrium, diffusion in solids, and heat transfer, as well as their application to engineering design. Required for materials science and engineering majors. Graduate/Undergraduate Equivalency: MSNE 503. Mutually Exclusive: Cannot register for MSNE 401 if student has credit for MSNE 503.

MSNE 402 - MECH PROPERTIES OF MATERIALS
Short Title: MECH PROPERTIES OF MATERIALS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 211 and (MSNE 211 or MSNE 301)
Description: Survey of the mechanical properties of solid materials. Includes basic mechanics, elasticity, plasticity, fracture, fatigue, creep, hardening mechanisms, mechanical testing, and structure-property relationships. Required for materials science and engineering majors. Graduate/Undergraduate Equivalency: MSNE 502. Mutually Exclusive: Cannot register for MSNE 402 if student has credit for MSNE 502.

MSNE 406 - PHYSICAL PROPERTIES OF SOLIDS
Short Title: PHYSICAL PROPERTIES OF SOLIDS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 211
Description: An introduction to band theory, exploring how the collective behavior of electrons determines the electrical, magnetic, and optical properties of materials. Required for materials science and engineering majors. Graduate/Undergraduate Equivalency: MSNE 506. Mutually Exclusive: Cannot register for MSNE 406 if student has credit for MSNE 506.

MSNE 407 - CAPSTONE DESIGN PROJECT I
Short Title: CAPSTONE DESIGN PROJECT I
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Laboratory
Credit Hours: 4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MSNE 304 and MSNE 311
Description: An interdisciplinary capstone design experience in materials science and nanoengineering. This course provides an opportunity for students to apply knowledge and skills acquired in previous courses to the solution of a realistic engineering problem. Teams of students will specify, design, and build an engineering system/device to meet a prescribed set of requirements. Must complete MSNE 408 to receive credit for MSNE 407 and both courses must be taken the same academic year. Required for MSNE majors in B.S. program. Instructor Permission Required.

MSNE 408 - CAPSTONE DESIGN PROJECT II
Short Title: CAPSTONE DESIGN PROJECT II
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: An interdisciplinary capstone design experience in materials science and nanoengineering. This course provides an opportunity for students to apply knowledge and skills acquired in previous courses to the solution of a realistic engineering problem. Teams of students will specify, design, and build an engineering system/device to meet a prescribed set of requirements. Must complete MSNE 407 to receive credit for MSNE 408 and both courses must be taken the same academic year. Required for MSNE majors in B.S. program. Instructor Permission Required.

MSNE 411 - MATERIALS CHARACTERIZATION FROM NANO TO MACRO
Short Title: MATERIALS CHARACTERIZATION
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (MSNE 211 or MSNE 301) and MSNE 304
Description: This course provides a comprehensive introduction to the fundamental operating principles and physical mechanisms underlying a variety of characterization techniques widely used in materials science. Students will explore the theoretical foundations and practical applications of methods such as electron diffraction, X-ray diffraction, optical and infrared spectroscopy, and scanning probe microscopy. Emphasis will be placed on understanding how each technique probes different aspects of material properties—such as structure, composition, and surface characteristics—and how to interpret the resulting data. Real-world case studies will be examined to illustrate the application of these techniques in research and industry, providing students with a deeper appreciation of their relevance and utility in solving materials-related challenges. Graduate/Undergraduate Equivalency: MSNE 511.

MSNE 413 - 3D PRINTING AND ADDITIVE MANUFACTURING: THEORY AND APPLICATIONS
Short Title: ADDITIVE MANUFACTURING
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Basic principles and applications of additive manufacturing (AM), Various AM processes. Materials science such as polymers, metals, ceramics, composites, and bio-materials for AM. Selection of material and process for design applications such as structures, electronics, biomedical, and consumer products. Hands-on experience and analysis from digital data to physical objects. Graduate/Undergraduate Equivalency: MSNE 513. Mutually Exclusive: Cannot register for MSNE 413 if student has credit for MSNE 513.

MSNE 414 - SOFT MATERIALS AND POLYMER PHYSICS
Short Title: SOFT MATERIALS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: By the end of the course, students should be able to evaluate and design polymer networks or hydrogels for various applications. A core aim is to relate structure of the polymeric network with its function. The course will include polymeric networks and also a module on soft materials, such as hydrogels, which are widely used in biological networks.

MSNE 415 - CERAMICS AND GLASSES
Short Title: CERAMICS AND GLASSES
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MSNE 211 or MSNE 301
Description: Fundamentals of ceramic and glassy materials, including phase relations, theoretical properties, structure, bonding, and design.

MSNE 417 - ORGANIC AND POLYMER SEMICONDUCTORS FOR ELECTRONICS AND PHOTONICS
Short Title: ORGANIC ELECTRONICS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): CHEM 211 or MSNE 211 or MSNE 301
Description: Covers physical and material concepts and engineering applications of organic semiconductors. Examines the relationship between chemical structure and molecular packing on optoelectronic properties such as band gap, charge carrier mobility, and luminescence efficiency. Topics include synthesis, electronic structure, physico-chemical characterization, doping, applications in LEDs, solar cells, photodetectors, transistors, and bioelectronics. Graduate/Undergraduate Equivalency: MSNE 517. Mutually Exclusive: Cannot register for MSNE 417 if student has credit for MSNE 517.

MSNE 419 - SOLID-STATE QUANTUM MATERIALS AND TECHNOLOGIES
Short Title: SOLID-STATE QUANTUM MATERIALS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: The aim of this course is to serve as an introduction to the state-of-the-art research in the field of quantum science, with a focus on the fundamental aspects of quantum materials used in these technologies. In particular, it will introduce three types of quantum systems, superconducting, spin, and photonic qubits, implemented in solid-state materials. Concepts such as Josephson junction, single electron transistors, quantum states of light, and cavity quantum electrodynamics will also be introduced to familiarize the students with the current research in this field. Graduate/Undergraduate Equivalency: MSNE 519. Mutually Exclusive: Cannot register for MSNE 419 if student has credit for MSNE 519.

MSNE 421 - SEMICONDUCTING MATERIALS: PROPERTIES, DEVICES, ANALYSIS
Short Title: SEMICONDUCTING MATERIALS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: This course introduces semiconducting materials to upper undergraduate/junior graduate students, providing a comprehensive knowledge of the fundamental properties of semiconductors and the principles of basic devices for materials scientists and engineers. Topics include: growth of semiconductors, electrons in semiconductors, current in semiconductors, semiconductors in real worlds, analysis of semiconductors, and next-generation semiconductors. Graduate/Undergraduate Equivalency: MSNE 521. Mutually Exclusive: Cannot register for MSNE 421 if student has credit for MSNE 521.

MSNE 433 - COMPUTATIONAL MATERIALS MODELING
Short Title: COMPUTATIONAL MATERIALS MODEL
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Physico-chemical principles augmented by ever-advancing computation technology have become a tool for explaining rich materials properties, designing nano-structures and their possible functionality. This course overviews basic quantum principles of materials structure, and a hierarchy of approximations broadly used in computational models. This includes classical mutli-body potentials, tight-binding approximations, electronic density functional theory methods, etc. Graduate/Undergraduate Equivalency: MSNE 533. Mutually Exclusive: Cannot register for MSNE 433 if student has credit for MSNE 533.

MSNE 435 - CRYSTALLOGRAPHY & DIFFRACTION
Short Title: CRYSTALLOGRAPHY & DIFFRACTION
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MSNE 211 or MSNE 301
Description: Study of crystals by diffraction techniques, focusing on x-ray, with an overview of electron and neutron diffraction as well as complementary techniques. Provides mathematical foundations and nomenclature for diffraction and related phenomena. Includes basics of crystallographic analysis and surface/point/space group symmetry, experiment design (sources, geometry, detectors), lab demos, and data analysis and interpretation. Required for undergraduate MSNE major. Meets with MSNE 535 (less course work for the undergraduate class). Graduate/Undergraduate Equivalency: MSNE 535. Mutually Exclusive: Cannot register for MSNE 435 if student has credit for MSNE 535.

MSNE 450 - MATERIALS SCIENCE SEMINAR
Short Title: MATERIALS SCIENCE SEMINAR
Department: Materials Science & NanoEng
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Seminar
Credit Hours: 0
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: A series of seminars on selected topics in Materials Science. Recommended for Materials Science and NanoEngineering majors.

MSNE 451 - MATERIALS SCIENCE SEMINAR
Short Title: MATERIALS SCIENCE SEMINAR
Department: Materials Science & NanoEng
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Seminar
Credit Hour: 1
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: A series of seminars on selected topics in Materials Science. Recommended for Materials Science and NanoEngineering majors.

MSNE 477 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Internship/Practicum, Laboratory, Lecture, Seminar, Lecture/Laboratory
Credit Hours: 1-4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Topics and credit hours may vary each semester. Contact department for current semester's topic(s). Repeatable for Credit.

MSNE 490 - MATERIALS SCIENCE RESEARCH PROJECTS
Short Title: MATERIAL SCIENCE RESEARCH PROJ
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 1-6
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Independent investigation of a specific topic or problem in materials science. Research under the direction of a selected faculty member. Instructor Permission Required. Repeatable for Credit.

MSNE 491 - SUPERVISED RESEARCH
Short Title: SUPERVISED RESEARCH
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 1-3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (MATH 101 or MATH 105) and (MATH 102 or MATH 106)
Description: Supervised research, reports and/or final reports required. Sponsorship by faculty member required. Instructor Permission Required. Repeatable for Credit.

MSNE 499 - CURRENT TOPICS
Short Title: CURRENT TOPICS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 1-9
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Designed for undergraduate materials science students. Topics vary from term to term. Please consult with the department for additional information.

MSNE 500 - MATERIALS SCIENCE SEMINAR
Short Title: MATERIALS SCIENCE SEMINAR
Department: Materials Science & NanoEng
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Seminar
Credit Hour: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: A series of seminars on selected topics in Materials Science. Required for Materials Science and Engineering majors. Repeatable for Credit.

MSNE 501 - GRADUATE STUDENT SEMINAR
Short Title: GRADUATE STUDENT SEMINAR
Department: Materials Science & NanoEng
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Seminar
Credit Hour: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Two graduate students will present every week, except for 1st year graduate students who will present 3 per class. Every week, students will be encouraged to fill out peer evaluation forms and include anonymous comments/suggestions for improving the presentation. The results of these comments will not be shared, but given to the presenter for their reference. Repeatable for Credit.

MSNE 502 - MECH PROPERTIES OF MATERIALS
Short Title: MECH PROPERTIES OF MATERIALS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Survey of the mechanical properties of solid materials. Includes basic mechanics, elasticity, plasticity, fracture, fatigue, creep, hardening mechanisms, mechanical testing, and structure-property relationships. Required for Materials Science and Engineering majors. Additional work required. Graduate/Undergraduate Equivalency: MSNE 402. Mutually Exclusive: Cannot register for MSNE 502 if student has credit for MSNE 402.

MSNE 503 - THERMODYNAMICS IN MATERIALS SCIENCE
Short Title: THERMODYNAMICS IN MAT SCIENCE
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Unified presentation of the kinetics and thermodynamics of mass and energy transport. Includes heterogeneous equilibrium, diffusion in solids, and heat transfer, as well as their application to engineering design. Required for Materials Science and Engineering majors. Graduate/Undergraduate Equivalency: MSNE 401. Mutually Exclusive: Cannot register for MSNE 503 if student has credit for MSNE 401.

MSNE 505 - MICROSTRUCTURE AND NANOSTRUCTURE EVOLUTION
Short Title: MICRO/NANO-STRUCTURE EVOLUTION
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Study of the thermodynamic and kinetic principles underlying structural evolution in materials at micro- and nanoscales. Includes atomic diffusion, phase transformations and morphological evolution of surfaces and interfaces under capillary and mechanical forces. Elucidation of atomistic mechanisms and mathematical treatment are emphasized. Undergraduates may register with instructor permission. Recommended Prerequisite(s): MSNE 503.

MSNE 506 - PHYSICAL PROPERTIES OF SOLIDS
Short Title: PHYSICAL PROPERTIES OF SOLIDS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Survey of the electrical, magnetic, and optical properties of metals, semiconductors, and dielectrics based upon elementary band theory concepts. Required for Materials Science and Engineering majors. Graduate/Undergraduate Equivalency: MSNE 406. Mutually Exclusive: Cannot register for MSNE 506 if student has credit for MSNE 406.

MSNE 510 - SCALING CONCEPTS IN 2D MATERIALS AND POLYMER PHYSICS
Short Title: SCALING CONCEPTS IN MATERIALS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The course is an introduction to symmetry breaking, scaling and universality in low dimensional materials and polymers. Using simple models as examples, the course addresses 2D crystals and melting, surface roughening, scaling properties of polymers, phase transitions and the mean field approach. It then goes over to explain how renormalization works in condensed matter, and how it gives rise to universality. Recommended Prerequisite(s): MSNE 401

MSNE 511 - MATERIALS CHARACTERIZATION FROM NANO TO MACRO
Short Title: MATERIALS CHARACTERIZATION
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course provides a comprehensive introduction to the fundamental operating principles and physical mechanisms underlying a variety of characterization techniques widely used in materials science. Students will explore the theoretical foundations and practical applications of methods such as electron diffraction, X-ray diffraction, optical and infrared spectroscopy, and scanning probe microscopy. Emphasis will be placed on understanding how each technique probes different aspects of material properties—such as structure, composition, and surface characteristics—and how to interpret the resulting data. Real-world case studies will be examined to illustrate the application of these techniques in research and industry, providing students with a deeper appreciation of their relevance and utility in solving materials-related challenges. Graduate/Undergraduate Equivalency: MSNE 411.

MSNE 512 - MATERIALS SCIENCE AND ENGINEERING WITH QUANTUM PHOTONICS
Short Title: QUANTUM MATERIALS & PHOTONICS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Introduction to the basic concepts of light-matter interaction with cavity electrodynamics, useful quantum (non-classical) properties of materials, and experimental techniques to probe/engineer materials with coherent or quantum light sources. Students are encouraged to have prior exposure to quantum mechanics and electronic properties of solids (or equivalent) before enrollment, although the principles will be refreshed at the beginning of the course. Cross-list: PHYS 512. Recommended Prerequisite(s): Quantum Mechanics; Physical Properties of Solids or Solid State Physics.

MSNE 513 - 3D PRINTING AND ADDITIVE MANUFACTURING: THEORY AND APPLICATIONS
Short Title: ADDITIVE MANUFACTURING
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Basic principles and applications of additive manufacturing (AM), Various AM processes. Materials science such as polymers, metals, ceramics, composites, and bio-materials for AM. Selection of material and process for design applications such as structures, electronics, biomedical, and consumer products. Hands-on experience and analysis from digital data to physical objects. Graduate/Undergraduate Equivalency: MSNE 413. Mutually Exclusive: Cannot register for MSNE 513 if student has credit for MSNE 413.

MSNE 517 - ORGANIC AND POLYMER SEMICONDUCTORS FOR ELECTRONICS AND PHOTONICS
Short Title: ORGANIC ELECTRONICS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Covers physical and material concepts and engineering applications of organic semiconductors. Examines the relationship between chemical structure and molecular packing on optoelectronic properties such as band gap, charge carrier mobility, and luminescence efficiency. Topics include synthesis, electronic structure, physico-chemical characterization, doping, applications in LEDs, solar cells, photodetectors, transistors, and bioelectronics. Graduate/Undergraduate Equivalency: MSNE 417. Mutually Exclusive: Cannot register for MSNE 517 if student has credit for MSNE 417.

MSNE 518 - MATERIALS SELECTION FOR BIOLOGICAL SYSTEMS
Short Title: BIO-MATERIAL INTERFACE(S)
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course will introduce students to various materials used to interface with biological systems, ranging from cells to organs. The goal(s) will be to understand the important materials properties to consider when building such systems, and general approaches of how to process materials in a bio-friendly manner. Content will be organized into different modules, including materials properties and processing, implantable materials systems, and in vitro materials systems. Each module will discuss how concepts relate to different tissue systems, with a focus often on the nervous system. Instruction will be delivered through a mixture of lectures, journal club-like discussions, seminars from experts in the area when applicable, and hands-on instruction. At the end, students will be expected to propose their own biological materials interface platform, motivate the selection of the materials, describe the device fabrication, and evaluate the advantages/disadvantages as compared to existing systems.

MSNE 519 - SOLID-STATE QUANTUM MATERIALS AND TECHNOLOGIES
Short Title: SOLID-STATE QUANTUM MATERIALS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The aim of this course is to serve as an introduction to the state-of-the-art research in the field of quantum science, with a focus on the fundamental aspects of quantum materials used in these technologies. In particular, it will introduce three types of quantum systems, superconducting, spin, and photonic qubits, implemented in solid-state materials. Concepts such as Josephson junction, single electron transistors, quantum states of light, and cavity quantum electrodynamics will also be introduced to familiarize the students with the current research in this field. Graduate/Undergraduate Equivalency: MSNE 419. Mutually Exclusive: Cannot register for MSNE 519 if student has credit for MSNE 419.

MSNE 521 - SEMICONDUCTING MATERIALS: PROPERTIES, DEVICES, ANALYSIS
Short Title: SEMICONDUCTING MATERIALS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course introduces semiconducting materials to upper undergraduate/junior graduate students, providing a comprehensive knowledge of the fundamental properties of semiconductors and the principles of basic devices for materials scientists and engineers. Topics include: growth of semiconductors, electrons in semiconductors, current in semiconductors, semiconductors in real worlds, analysis of semiconductors, and next-generation semiconductors. Graduate/Undergraduate Equivalency: MSNE 421. Mutually Exclusive: Cannot register for MSNE 521 if student has credit for MSNE 421.

MSNE 522 - EMERGING MATERIALS FOR NANOELECTRONICS DEVICES
Short Title: MATERIALS FOR NANOELECTRONICS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course provides a comprehensive overview of current and emerging material platforms for modern nanoelectronics. It aims to bridge the gap between modern topics in material science and its implementation in practical devices. Beginning with the historical development of the transistor, the course examines technological advancements such as high-k dielectrics, ferroelectric transistors, and contact/channel engineering. Finally, it broadens its focus to emerging materials, covering 2D materials, III-V compounds, Carbon Nanotubes, Complex Oxides, Spintronics, and NEMS/MEMS devices.

MSNE 523 - PROPERTIES, SYNTHESIS AND DESIGN OF COMPOSITE MATERIALS
Short Title: DESIGN OF COMPOSITE MATERIALS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Study of the science of interfaces and the properties that govern their use in composite materials. Not offered every year. The study of composite processing and methods for synthesis polymer, metal and ceramic matrix composition.

MSNE 532 - ATOMISTIC MODELING AND AI FOR MATERIALS DESIGN
Short Title: MODELING AND AI FOR MATERIALS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Advances in first-principles simulation, high-throughput computation, and artificial intelligence have transformed modern materials science. This course introduces the methods and workflows used in computational materials design and discovery, with emphasis on density functional theory, materials databases, automated workflows, machine learning, machine-learned interatomic potentials, and emerging generative AI approaches. Students will gain practical experience using modern computational tools to set up, run, and interpret simulations and data-driven models for materials problems. Hands-on exercises using state-of-the-art codes, literature discussions, and a final project will reinforce the major concepts and applications.

MSNE 533 - COMPUTATIONAL MATERIALS MODELING
Short Title: COMPUTATIONAL MATERIALS MODEL
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Physico-chemical principles augmented by ever-advancing computation technology have become a tool for explaining rich materials properties, designing nano-structures and their possible functionality. This course overviews basic quantum principles of materials structure, and a hierarchy of approximations broadly used in computational models. This includes classical mutli-body potentials, tight-binding approximations, electronic density functional theory methods, etc. MSNE 533 requires additional work. Graduate/Undergraduate Equivalency: MSNE 433. Mutually Exclusive: Cannot register for MSNE 533 if student has credit for MSNE 433.

MSNE 534 - NANOSCIENCE AND NANOTECHNOLOGY I
Short Title: NANOSCIENCE & NANOTECHNOLOGY
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Enrollment is open to all students. Undergraduate enrollment requires instructor permission via special registration form. An introduction to the basic principles of nanoscience and nanotechnology. Size dependent physical properties of nanoscopic solids will be described using solid state physics and molecular orbital theory as a foundation. Wet chemical techniques that produce nanoscale materials (e.g. carbon nanotubes, semiconductor and metallic nanocrystals, dendrimers...) will be introduced in the second half of the semester. Expected to be taught Spring 2019. Cross-list: CEVE 533, CHEM 533.

MSNE 535 - CRYSTALLOGRAPHY & DIFFRACTION
Short Title: CRYSTALLOGRAPHY & DIFFRACTION
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Study of crystals by diffraction techniques, focusing on x-ray, with an overview of electron and neutron diffraction as well as complementary techniques. Provides mathematical foundations and nomenclature for diffraction and related phenomena. Includes basics of crystallographic analysis and surface/point/space group symmetry, experiment design (sources, geometry, detectors), lab demos, and data analysis and interpretation. Required for undergraduate MSNE major. Meets with MSNE 435 (additional work for the graduate version). Cross-list: PHYS 535. Graduate/Undergraduate Equivalency: MSNE 435. Mutually Exclusive: Cannot register for MSNE 535 if student has credit for MSNE 435.

MSNE 538 - COMPUATIONAL NANOSCIENCE FOR GREEN INFRASTRUCTURE
Short Title: COMPUTATIONAL NANOSCIENCE
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Computational methods such as first principles, kinetic Monte Carlo (KMC), classical MC (in Canonical, Grand Canonical, and isobaric-isothermal ensembles), and classic MD in predicting materials formation and properties. Case studies include cementitious materials, metals, and thermoelectric materials. Other case studies are possible depending on the student's background and instructor's approval. Cross-list: CEVE 538.

MSNE 540 - THIN FILM AND DEVICE PHYSICS
Short Title: THIN FILM AND DEVICE PHYSICS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course is designed to equip junior graduate students with the practical skills for nanomaterials growth and fabrication and fundamental knowledge of semiconductor devices as materials scientists. The topics include: thin film deposition, lithography, etching, properties of semiconductors, field effect transistor, metal-semiconductor contact and more

MSNE 555 - MATERIALS IN NATURE AND BIO-MIMETIC STRATEGIES
Short Title: BIO-MIMETIC STRATEGIES
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This graduate level course will discuss the origin of several materials that exists in nature from a technology perspective and strategies to replicate them using synthetic materials processing protocols. Silicates, carbon based materials, abalone shell, bone etc. will be used to discuss the fascinating architecture developed by nature. Similarly several functional structures designed by nature such as Gecko tape and IR sensors will be discussed for designing bio-medic structure and devices.NOTE: Not offered every year. Graduate/Undergraduate Equivalency: MSNE 222.

MSNE 560 - COLLOIDAL AND INTERFACIAL PHENOMENA
Short Title: COLLOIDAL & INTERFACIAL PHENOM
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The course will provide knowledge into the fundamentals of colloidal interactions (e.g., stabilisation, adsorption, self-assembly) and the techniques currently applied for their assessment. Apart from the theoretical background, the course will also provide applicable knowledge by covering current and emerging applications involving these phenomena. Interfacial tension, wetting and spreading, contact angle hysteresis, interaction between colloid particles, stability of interfaces, flow and transport near interfaces will be covered. NOTE: Offered in alternative year with MSNE 594/CHBE 594. Cross-list: CHBE 560.

MSNE 569 - SCIENCE AND APPLICATIONS OF CORROSION SCIENCE AND ENGINEERING
Short Title: CORROSION SCIENCE& ENGINEERING
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): MSCI 301 or MSNE 301
Description: Students will learn basics of corrosion science of metals and alloys exposed to different classes of conditions, prevalent forms of corrosion, consequences of corrosion and corrosion mitigation approaches in a range of industries. Discussion of nano science aspects related to corrosion control in industry will be included.

MSNE 570 - SENIOR DESIGN THESIS PROJECT
Short Title: SENIOR DESIGN THESIS PROJECT
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Independent Study
Credit Hours: 2
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: A design project in the materials science field will be undertaken by the student in close collaboration with at least one materials science faculty member.

MSNE 571 - SENIOR DESIGN THESIS PROJECT
Short Title: SENIOR DESIGN THESIS PROJECT
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Independent Study
Credit Hours: 2
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: A design project in the materials science field will be undertaken by the student in close collaboration with at least one materials science faculty member. Instructor Permission Required.

MSNE 580 - MICROSCOPY METHODS IN MATERIALS SCIENCE
Short Title: MICROSCOPY METHODS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This course covers theory and applications of electron microscopy techniques with an emphasis on transmission and scanning transmission electron microscopy (TEM, STEM). Topics include modern instrumentation and hardware, electron diffraction, imaging modes, tomography, and spectroscopy (energy dispersive x-ray spectroscopy (EDS), electron-energy loss spectroscopy (EELS), cathodoluminescence (CL)). Previous experience with electron microscopes recommended. This course includes lab demos of SEM and TEM. Cross-list: CHEM 580.

MSNE 581 - MICRO AND NANO HEAT TRANSPORT METHODOLOGIES AND DESIGN
Short Title: MICRO & NANO HEAT TRANSPORT
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to students with a major in Mechanical Engineering or Materials Science & NanoEng. Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): MECH 481
Description: A thorough explanation of the methodologies used for solving conduction, convection and radiation heat transport problems in macro, micro and nanosystems. Phonon, photon and electron transfer fundamentals. Equilibrium Statistics. Basic kinetic theory and transport properties of ideal gases. Microchannel heat transfer. Nanofluid heat transfer. Non-Fourier heat Conduction. Boltzmann transport equation. Molecular dynamics and lattice dynamics numeric methods. Applications and design problems in contemporary technologies. To be taught alternating years for MECH and MSNE Seniors and Graduate students. Cross-list: MECH 581.

MSNE 589 - ETHICS & SAFETY FOR MATERIALS ENGINEERS
Short Title: ETHICS & SAFETY FOR MATER ENG
Department: Materials Science & NanoEng
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Seminar
Credit Hour: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Moral duty as well as legal and contractual obligations related to the practice of materials engineering. Issues of importance include safety, conflicts of interest, noncompetition & nondisclosure agreements, as well as confidential and proprietary information. Several examples of ethical lapses and various fraudulent activities will be reviewed, as well as “special processes” which pose the greatest risk for ethics violations. Graduate/Undergraduate Equivalency: MSNE 389.

MSNE 593 - INTRODUCTION TO POLYMER PHYSICS AND ENGINEERING
Short Title: POLYMER PHYSICS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): CHEM 211 and CHEM 212
Description: The course focuses on demonstrating how the physical properties of polymers can be understood from simple models. Students will be introduced to the terminology and mathematics involved in the physical understanding of polymer systems. The course is intended for students who would like to gain an understanding of modern approaches to polymer physics. NOTE: Not offered every year. Cross-list: CHBE 593.

MSNE 594 - PROPERTIES OF POLYMERS
Short Title: PROPERTIES OF POLYMERS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): (CHEM 211 or CHEM 251) and (MATH 211 or MATH 221)
Description: The course will introduce basic concepts in polymer science including the synthesis and chemical modification of polymers as well as physical properties of polymers. Topics include approaches to polymer synthesis, processing and characterization of polymer materials, and an introduction to mathematical models applied to describe the structure and dynamics of polymeric materials. NOTE: Offered in alternative year with MSNE 560/CHBE 560. Cross-list: CHBE 594. Repeatable for Credit.

MSNE 599 - LAB ROTATIONS AND ADVISOR SELECTION
Short Title: LAB ROTATION ADVISOR SELECTION
Department: Materials Science & NanoEng
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Laboratory
Credit Hour: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Open to first year doctoral students. Students will rotate through three research groups to familiarize themselves with the research projects and environment offered by each group, and complete the advisor selection form at the end of the rotations.

MSNE 609 - RISK ASSESSMENT AND ASSET INTEGRITY IN OIL AND GAS PRODUCTION AND REFINING OPERATIONS I
Short Title: OIL AND GAS ASSET INTEGRITY I
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The course integrates risk assessment and mitigation, asset integrity management, corrosion control and materials selection across the oil and gas value chain, from production to refining and retail. The full course covers 2 semesters. Session "I," to be delivered in the Spring 2017 semester. Session "II" will be delivered in the Fall 2017 semester. Instructor Permission Required. Cross-list: CHBE 609.

MSNE 613 - SPECIAL TOPICS I
Short Title: SPECIAL TOPICS I
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: For Spring 2023:The course integrates fundamental knowledge of vibrational [Raman ,IR], electronic, magnetic resonance and X-ray spectroscopic techniques [including XPS and AUGER] to solve challenges in applied science and engineering research. Theoretical principles and symmetry rules are used to predict, generate and interpret atomic and molecular spectra. Instrumental component of the course gives special attention to operando in situ characterization. Will be a three-credit-hour course. Repeatable for Credit.

MSNE 614 - SPECIAL TOPICS II
Short Title: SPECIAL TOPICS II
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: INDUSTRIAL NANOTECHNOLOGY. The course will provide knowledge of industrial applications of nanotechnology enabled by research advances in different areas of nanoscience and engineering, including materials science, chemistry, physics, energy, environment, and aerospace. Overview of synthesis of nanomaterials through bottom-up and top-down strategies. Characterization of nanomaterials, particle size, shape and surface properties relationships, surface modification tailored to specific industrial applications. Safety related to nanomaterials and nanostructures in the environment and industrial nanotechnology development projects. Discussion of selected application case studies originating from nanotechnology invention and commercial implementation. At the end of the course, student will be able to explain the advantages of nanotechnology, give examples of current industrial applications of nanotechnology, and forecast the future technological advancements and increasing role of nanotechnology in each industry. This will be a 3 credit hour course. Repeatable for Credit Repeatable for Credit.

MSNE 615 - SPECIAL TOPICS III
Short Title: SPECIAL TOPICS III
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: MATERIALS ELECTROCHEMISTRY-The course emphasizes the principles of electrochemical devices including batteries, supercapacitors, fuel cells, and electrochemical sensors. Topics will emphasize the latest trends and challenges in the chemistry, materials, and physics involved in the materials design, electrochemical measurements, and characterization of these devices as well as the thermodynamics and kinetics related to different electrode processes at the macroscopic and microscopic levels. This will be a three-credit-hour course. Repeatable for Credit. Repeatable for Credit.

MSNE 616 - AUTOMOTIVE ENGINEERING: MATERIALS AND DYNAMICS
Short Title: AUTOMOTIVE ENGINEERING
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Discussion of the engineering and materials technology that is involved in modern automotive design. Topics include: chassis design and construction; composite design and fabrication; aerodynamics and ground effects; suspension dynamics; performance technology. External expert speakers will provide a real-world perspective. Course will only be offered with sufficient demand. Check with the instructor. Instructor Permission Required. Repeatable for Credit.

MSNE 617 - AUTOMOTIVE ENGINEERING: LAB
Short Title: AUTOMOTIVE ENGINEERING: LAB
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Laboratory
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Laboratory application of engineering skills towards the materials technology and dynamics of chassis design, composite design, and fabrication, aerodynamics, and performance technology. Not offered every year. Instructor Permission Required. Recommended Prerequisite(s): MSCI 616 or MSNE 616. Repeatable for Credit.

MSNE 618 - RISK ASSESSMENT AND ASSET INTEGRITY IN OIL AND GAS PRODUCTION AND REFINING OPERATIONS II
Short Title: OIL AND GAS ASSET INTEGRITY II
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The course integrates risk assessment and mitigation, asset integrity management, corrosion control and materials selection across the oil and gas value chain, from production to refining and retail. The full course covers 2 semesters. Session "I," to be delivered in the Spring 2017 semester. Session "II" will be delivered in the Fall 2017 semester. Instructor Permission Required. Cross-list: CHBE 618.

MSNE 621 - M.M.S. RESEARCH PROJECT I
Short Title: M.M.S. RESEARCH PROJECT I
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This is the first part of the M.M.E. research project course. The faculty advisor, taking into account the background and research interests of the student as well as the research interests of the faculty advisor, will determine the contents. Course requirements will include a final report. Instructor Permission Required. Repeatable for Credit.

MSNE 622 - M.M.S. RESEARCH PROJECT II
Short Title: M.M.S. RESEARCH PROJECT II
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This is the second part of the M.M.E. research project and continuation of MSNE 621. Course requirements will include a final report. Instructor Permission Required. Repeatable for Credit.

MSNE 650 - NANOMATERIALS AND NANOMECHANICS
Short Title: NANOMATERIALS & NANOMECHANICS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: The primary goal of this course is to introduce important current developments in the field of nanomaterials and nanomechanics. The course will discuss synthesis and characteration of nanomaterials, the behaviors especially mechanical behaviors in the broad sense of such materials, and their technological applications. The basic physics and fundamental mechanisms responsible for nanoscale induced changes in properties will be stressed.

MSNE 677 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Materials Science & NanoEng
Grade Mode: Standard Letter
Course Type: Internship/Practicum, Laboratory, Lecture, Seminar, Independent Study
Credit Hours: 1-4
Restrictions: Enrollment is limited to Graduate or Visiting Graduate level students.
Course Level: Graduate
Description: Topics and credit hours vary each semester. Contact department for current semester's topic(s). Repeatable for Credit.

MSNE 700 - TEACHING PRACTICUM
Short Title: TEACHING PRACTICUM
Department: Materials Science & NanoEng
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Internship/Practicum
Credit Hour: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Students who serve as teaching assistants are required to register this course. Students will hold recitations or office hours and assist instructors in lectures. Open to graduate students in Materials Science and NanoEngineering and only in exceptional circumstances to undergraduates. Repeatable for Credit.

MSNE 800 - RESEARCH AND THESIS
Short Title: RESEARCH AND THESIS
Department: Materials Science & NanoEng
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Research
Credit Hours: 1-12
Restrictions: Enrollment is limited to students with a major in Materials Science & NanoEng. Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Thesis research Repeatable for Credit.

Description and Code Legend

Note: *Internally, the university uses the following descriptions, codes, and abbreviations for this academic program. The following is a quick reference:*

Course Catalog/Schedule

- Course offerings/subject code: MSNE

Home School Description and Code

- Engineering and Computing: EN

Home Department Description and Code

- Materials Science and NanoEngineering: MSNE

Undergraduate Degree Descriptions and Codes

- Bachelor of Arts degree: BA
- Bachelor of Science in Materials Science and NanoEngineering degree: BSMSNE

Undergraduate Major Description and Code

- Major in Materials Science and NanoEngineering: MSNE

Undergraduate Degree Program Option Descriptions and Codes*

- Degree Program Option (BA degree): BA-ENGI
- Degree Program Option (BSMSNE degree): BSMSNE-ENGI

Graduate Degree Descriptions and Codes

- Master of Materials Science and NanoEngineering degree: MMSNE
- Master of Science degree: MS
- Doctor of Philosophy degree: PhD

Graduate Degree Program Description and Code

- Degree Program in Materials Science and NanoEngineering: MSNE

Graduate Degree Program Option Description and Code*

- Degree Program Option - Thesis (MS degree): MS-THESIS

CIP Code and Description [1]

- **MSNE** Major/Program: CIP Code/Title: *14.1801 - Materials Engineering*

* *Systems Use Only: this information is used solely by internal offices at Rice University (such as OTR, GPS, etc.) and primarily within student information systems and support.*

[1] Classification of Instructional Programs (CIP) 2020 Codes and Descriptions from the National Center for Education Statistics: https://nces.ed.gov/ipeds/cipcode/.