

# MATERIALS SCIENCE AND NANOENGINEERING

## Contact Information

### Materials Science and NanoEngineering

<https://msne.rice.edu/>

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### Pulickel M. Ajayan

Department Chair

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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 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 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 \(https://msne.rice.edu/\)](https://msne.rice.edu/).

## Bachelor's Programs

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

[programs/engineering/materials-science-nanoengineering/materials-science-nanoengineering-bsmsne/\)](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 \(https://ga.rice.edu/programs-study/departments-programs/engineering/materials-science-nanoengineering/materials-science-nanoengineering-mmsne/\)](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 \(https://ga.rice.edu/programs-study/departments-programs/engineering/materials-science-nanoengineering/materials-science-nanoengineering-ms/\)](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 \(https://ga.rice.edu/programs-study/departments-programs/engineering/materials-science-nanoengineering/materials-science-nanoengineering-phd/\)](https://ga.rice.edu/programs-study/departments-programs/engineering/materials-science-nanoengineering/materials-science-nanoengineering-phd/)

## Chair

Pulickel M. Ajayan

## Associate Chair

Jun Lou

## Professors

Enrique V. Barrera  
Lane Martin  
Ramamoorthy Ramesh  
Boris I. Yakobson

## Associate Professor

Ming Tang

## Assistant Professors

Yimo Han  
HaeYeon Lee  
Hanyu Zhu

## Research Professor

Robert Vajtai

## Associate Research Professors

Wade Adams  
Evgeni Penev  
Alberto Pimpinelli

## Assistant Research Professor

Muhammad Maksud Rahman

## Professor in the Practice

Ricardo Zednik

## Lecturers

Randy John  
Ahmad Kabbani

Valery N. Khabashesku  
Venkataraman Swaminathan

## Joint Appointments

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

## Adjunct Professors

Ghanashyam Acharya  
Sivaram Arepalli  
Jaime Bonilla-Rios  
Peter Boul  
Lijie Ci  
Zachary Cordero  
Feng Ding  
Eilaf Egap  
Baburaj Eranezhuth  
Ashish Garg  
Sergio D. Kapusta  
Francisco Robles Hernandez  
Ajit Roy  
Glaura Goulart Silva  
Abhishek Kumar Singh  
Edwin L. Thomas  
Nikhil Verghese  
Zhao Wang

*For Rice University degree-granting programs:*

To view the list of official course offerings, please see [Rice's Course Catalog \(https://courses.rice.edu/admweb/!SWKSCAT.cat?p\\_action=cata\)](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 \(https://courses.rice.edu/admweb/!SWKSCAT.cat\)](https://courses.rice.edu/admweb/!SWKSCAT.cat)

## Materials Science & NanoEng (MSNE)

**MSNE 201 - INTRODUCTION TO NANOTECHNOLOGY FOR ENGINEERS**

**Short Title:** INTRO TO NANOTECH FOR ENGR

**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 nanomaterials and their applications in engineering, technology, chemistry, energy, biology, and medicine. General discussion of nanotechnology, from multidisciplinary research to consumer products, suitable for all levels and specializations. Students will develop the understanding needed to separate the hype from the real in one of the most dynamic and prolific areas of research in the last ten years. Includes demonstrations, student-lead projects, and lab tours. Required for MSNE majors.

**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 365 - NANOMATERIALS FOR ENERGY****Short Title:** NANOMATERIALS FOR ENERGY**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:** This course will introduce students to the fundamental science of nanomaterials. Many of the concepts will be explained by drawing from applications in sustainability (photovoltaics, solar-to-fuel conversion thermionic, thermoelectric, fuel cells). Students will design a lab demo from scratch using amongst others the infrastructure provided by the photonics measurement lab. Cross-list: ELEC 365.

**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:** 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 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/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) and MSNE 304**Description:** Sample preparation, visible light microscopy, optical interferometry used for profilometry, scanning electron microscopy, x-ray spectroscopy and microanalysis, hardness testing, calorimetry, and thermo-gravimetric analysis. Applications include evaluation of composition, structure, properties, and defects as well as fractography and failure analysis. Structures of primary interest are those resulting from nonequilibrium processing. Required for the BS-MSNE. 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 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 - ELECTRONIC, OPTICAL AND MAGNETIC PROPERTIES OF POLYMERS****Short Title:** POLYMER 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 electronic polymers. Examines the structural origins of the diverse electronic, optoelectronic, photonic and magnetic properties of conjugated polymers. Topics include synthesis, electronic structure, physico-chemical characterization, applications in LEDs, solar cells, transistors, spintronics, and bioelectronics. Graduate/Undergraduate Equivalency: MSNE 517. Mutually Exclusive: Cannot register for MSNE 417 if student has credit for MSNE 517.**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 multi-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), 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 437 - CRYSTALLOGRAPHY & DIFFRAC LAB****Short Title:** CRYSTALLOGRAPHY & DIFFRAC LAB**Department:** Materials Science & NanoEng**Grade Mode:** Standard Letter**Course Type:** Laboratory**Credit Hour:** 1**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MSNE 435 (may be taken concurrently)**Description:** Selected laboratory experiments in materials science, focusing on lattice symmetry, crystallography, phase identification, and metallurgy. Required for undergraduate MSNE major. Prerequisite MSNE 435 may be take concurrently. Graduate/Undergraduate Equivalency: MSNE 537. Mutually Exclusive: Cannot register for MSNE 437 if student has credit for MSNE 537.**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:** Seminar, Lecture, Laboratory, Internship/Practicum**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/Laboratory**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Sample preparation, visible light microscopy, optical interferometry used for profilometry, scanning electron microscopy, x-ray spectroscopy and microanalysis, hardness testing, calorimetry, and thermo-gravimetric analysis. Applications include evaluation of composition, structure, properties, and defects as well as fractography and failure analysis. Structures of primary interest are those resulting from nonequilibrium processing. Instructor Permission Required. Graduate/Undergraduate Equivalency: MSNE 411.

**MSNE 512 - QUANTUM MATERIALS ENGINEERING****Short Title:** QUANTUM MATERIALS 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

**Description:** Introduction to the basic concepts of useful quantum (non-classical) properties of materials, as well as experimental techniques to engineer materials, with an emphasis on various optical spectroscopy. 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 - ELECTRONIC, OPTICAL AND MAGNETIC PROPERTIES OF POLYMERS****Short Title:** POLYMER 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 electronic polymers. Examines the structural origins of the diverse electronic, optoelectronic, photonic and magnetic properties of conjugated polymers. Topics include synthesis, electronic structure, physico-chemical characterization, applications in LEDs, solar cells, transistors, spintronics, and bioelectronics. Graduate/Undergraduate Equivalency: MSNE 417. Mutually Exclusive: Cannot register for MSNE 517 if student has credit for MSNE 417.

**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 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 multi-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**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), 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 537 - CRYSTALLOGRAPHY & DIFFRAC LAB****Short Title:** CRYSTALLOGRAPHY & DIFFRAC LAB**Department:** Materials Science & NanoEng**Grade Mode:** Standard Letter**Course Type:** Laboratory**Credit Hour:** 1**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

**Description:** Selected laboratory experiments in materials science, focusing on lattice symmetry, crystallography, phase identification, and metallurgy. Required for undergraduate MSNE major. Credit may be given for only one, MSNE 537 or MSNE 437. Graduate/Undergraduate Equivalency: MSNE 437. Recommended Prerequisite(s): MSNE 535 Mutually Exclusive: Cannot register for MSNE 537 if student has credit for MSNE 437.

**MSNE 538 - COMPUTATIONAL 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 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-medical 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. Can be taken alone or concurrently with lab course MSNE 582. 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 582 - ELECTRON MICROSCOPY CENTER LAB****Short Title:** ELECTRON MICROSCOPY CENTER LAB**Department:** Materials Science & NanoEng**Grade Mode:** Standard Letter**Course Type:** Laboratory**Credit Hour:** 1**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Corequisite:** MSNE 580**Description:** Hands-on laboratory using the instruments in the electron microscopy center. The students will gain the knowledge necessary to operate the instruments and analyze data independently. MSNE 582 must be taken concurrently with MSNE 580; CHEM 582 must be taken concurrently with CHEM 580. Cross-list: CHEM 582.**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. Department Permission Required.**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:** "Quantum materials for disruptive technologies". Quantum materials currently represent a fast-growing area of research in materials science. Many known materials such as Heusler alloys and thermoelectric materials are now studied under the purview of quantum materials to exploit their potential in quantum information science. Many new topological materials (e.g., NaZnBi, MnBi<sub>2</sub>Te<sub>4</sub>) are being identified with exotic properties offering the potential for new applications. Perovskites have emerged as the promising solar cell material and as a replacement for the traditional silicon based solar cells. New functional materials, tailored to the applications, will be discovered using artificial intelligence and machine learning techniques. Topological design of layered materials, such as the core-shell architectures, will be a new tool to leverage topology-property relationships and discover new applications or as an upgrade for existing designs. In this course we will examine the emerging materials for applications in diverse areas such as energy, electronics, health, quantum information science. An important component of the course would be to expose students to design material solutions to invent new applications and/or to innovate for disruptive technologies. 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 characterization 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

## 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

## 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

## CIP Code and Description <sup>1</sup>

- MSNE Major/Program: CIP Code/Title: 15.1601 - Nanotechnology

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