MGT 400E Auditing and Assurance 4
Lecture, 20 hours per quarter; discussion, 20 hours per quarter. Prerequisite(s): graduate standing and consent of instructor or admission to the Master of Professional Accountancy (M.P.Ac.) program. Audit and assurance concepts necessary for graduate work.

MGT 402 Business Career Professional Development Workshop 2 Seminar, 1 hour; consultation, 1 hour; individual study,4 hours. Prerequisite(s): graduate standing in a program in the Anderson Graduate School of Management. Provides skill development and experience to network in person and via social media outlets. Offers a platform for practical implementation of effective job search strategies in various industries. Sets stage for development and presentation of student's ideas clearly at internship and job interviews. Graded Satisfactory (S) or No Credit (NC).

MGT 403 Review of Quantitative Methods For Management 4 Lecture, 3 hours; individual study, 3 hours. Prerequisite(s): graduate standing; or consent of instructor. Reviews quantitative concepts and techniques related to the various functional areas of management. Topics include properties of functions, systems of equations and matrices (linear algebra), differentiation and integration (calculus), and basic probability concepts. Graded Satisfactory (S) or No Credit (NC).

MGT 404 Communications, Leadership, Teams, and Ethics 2 Lecture, 7 hours per quarter; workshop, 28 hours per quarter. Prerequisite(s): graduate standing. Uses case discussions, presentations, and theoretically informed readings to develop communication, presentation, and leadership skills; examine the principles of effective teamwork; and introduce representative ethical issues confronting managers. Not for degree credit. Graded Satisfactory (S) or No Credit (NC).

Marxist Studies Minor

College of Humanities, Arts, and Social Sciences

Bronwyn Leebaw, Chair
Sproul 4124
(951) 827-1473; marxiststudies.ucr.edu

Committee in Charge

Bronwyn Leebaw, Chair (Political Science)
Jennifer Doyle (English)
Alfonso Gonzalez, (Ethnic Studies)
Daryle Williams, Dean, *ex officio*

The Marxist Studies minor integrates courses from various disciplines in order to examine the theory and main applications of Marxism in the social sciences and humanities disciplines.

Requirements for the minor (24 units)

1. Theory, method, and history of thought requirement
   a) PHIL 153
2. Four courses from the following dealing with applications of Marxist studies in various fields:
   a) ANTH 131
   b) CPLT 180X
   c) ECON 175
   d) POSC 160
   e) WRLT 170/ETST 170

See Minors under the College of Humanities, Arts, and Social Sciences in the Colleges and Programs section of this catalog for additional information on minors.

Materials Science and Engineering

Subject abbreviation: MSE
The Marlan and Rosemary Bourns College of Engineering

Juchen Guo, Ph.D., Chair
Materials Science and Engineering Program
313 Materials Science and Engineering Building;
(951) 827-4414
https://www.mse.ucr.edu/

Program Faculty
Distinguished Professors

Reza Abbaschian, Ph.D. (Mechanical Engineering)
Alexander Balandin, Ph.D. (Electrical and Computer Engineering)
Umar Mohideen, Ph.D. (Physics and Astronomy)
Ashok Mulchandani, Ph.D. (Chemical and Environmental Engineering)
Kambiz Vafai, Ph.D. (Mechanical Engineering)
Michael R. Zachariah, Ph.D. (Chemical and Environmental Engineering)
Francisco Zaera, Ph.D. (Chemistry)

Professors

Christopher Bardeen, Ph.D. (Chemistry)
Ludwig Bartels, Ph.D. (Chemistry)
Pingyun Feng, Ph.D. (Chemistry)
Cheryl Hayashi, Ph.D. (Biology)
De-en Jiang, Ph.D. (Chemistry)
Roger K. Lake, Ph.D. (Electrical and Computer Engineering)
Jianlin Liu, Ph.D. (Electrical and Computer Engineering)
Stefano Lonardi, Ph.D. (Computer Science and Engineering)
Christopher Lynch, Ph.D. (Dean, BCOE)
Allen Mills, Ph.D. (Physics and Astronomy)
Leonard Mueller, Ph.D. (Chemistry)
Cengiz Ozkan, Ph.D. (Mechanical Engineering)
Mihri Ozkan, Ph.D. (Electrical and Computer Engineering)
Victor Rodgers, Ph.D. (Bioengineering)
Jing Shi, Ph.D. (Physics and Astronomy)
Harry W.K. Tom, Ph.D. (Physics and Astronomy)
Kathryn Uhrich, Ph.D. (Dean, College of Natural & Agricultural Sciences)
Valentine Vullev, Ph.D. (Bioengineering)
Jianzhong Wu, Ph.D. (Chemical Engineering)
Guanshui Xu, Ph.D. (Mechanical Engineering)
Jory Yarmoff, Ph.D. (Physics and Astronomy)
Yadong Yin, Ph.D. (Chemistry)

Associate Professors

Shane Cybart, Ph.D. (Mechanical Engineering)
Boniface P.T. Fokwa, Ph.D. (Chemistry)
Nathaniel Gabor, Ph.D. (Physics and Astronomy)
Juan Pablo Giraldo, Ph.D. (Botany and Plant Sciences, CNAS)
Juchen Guo, Ph.D. (Chemical and Environmental Engineering)
Elaine Haberer, Ph.D. (Electrical and Computer Engineering)
Huinan Liu, Ph.D. (Bioengineering)
Ming Liu, Ph.D. (Electrical and Computer Engineering)
Lorenzo Mangolini, Ph.D. (Mechanical Engineering)
Jin Nam, Ph.D. (Bioengineering)
Masaru Rao, Ph.D. (Mechanical Engineering)
Bryan Wong, Ph.D. (Chemical and Environmental Engineering)
Ruoxue Yan, Ph.D. (Chemical and Environmental Engineering)

Assistant Professors

Igor Barsukov, Ph.D. (Physics and Astronomy)
Xi Chen, Ph.D. (Electrical and Computer Engineering)
Sinisa Coh, Ph.D. (Mechanical Engineering)
Yongtao Cui, Ph.D. (Physics and Astronomy)
Kandis Leslie Gilliard-AbdulAziz (Chemical and Environmental Engineering)
P. Alexander Greaney, Ph.D. (Mechanical Engineering)
Chen Li, Ph.D. (Mechanical Engineering)
Luat Thanh Vuong, Ph.D. (Mechanical Engineering)
Richard Wilson, Ph.D. (Mechanical Engineering)
Peng Wei, Ph.D. (Physics and Astronomy)
**

Adjunct Professors

Nissim Amos, Ph.D. (The Center for Nanotechnology, Kinneret Academic College)
Krassimir Bozhilov, Ph.D. (Central Facility for Advanced Microscopy and Microanalysis)
Cheryl Hayashi, Ph.D. (American Museum of Natural History)
Alexander Khitun, Ph.D. (Electrical and Computer Engineering)
David Kisailus, Ph.D. (Materials Science and Engineering, University of California, Irvine)
Alfredo Martinez-Morales, Ph.D. (Managing Director of the Southern California Research Initiative for Solar Energy (SC-RISE)
Nosang V. Myung (Chemical and Biomolecular Engineering)
Mahesh R. Neupane, Ph.D. (ARL-WEST Los Angeles)
Aaron Wiest, Ph.D. (Naval Surface Warfare Center - Corona)

Major

The B.S. degree in Materials Science and Engineering is offered jointly by the five participating departments of The Marlan and Rosemary Bourns College of Engineering. The program aims to produce students who are effective team players in materials engineering or related engineering, science or managerial positions, who use and improve on their skills in the job; who can enter into graduate or professional degree programs; and who are responsible engineers, professionals or scientists demonstrating ethical and professional responsibility and continuing to learn through a variety of educational experiences.

The Materials Science and Engineering Program Educational Objectives are to prepare our graduates to impact an evolving society by producing materials science and engineering constituents who:

- are successful in both education and industry
- can demonstrate professionalism and leadership in cutting edge interdisciplinary materials science and engineering practices
- can utilize an understanding of the principles of materials science and engineering to improve existing systems and innovate and design next generation technologies
- will contribute effectively as individuals, team members, and/or leaders to achieve personal, group and institutional goals.

The Materials Science and Engineering B.S. degree program at UCR is accredited by the Engineering Accreditation Commission of ABET, **abet.org**.

Change of Major Criteria

All students who request a change of major to Materials Science and Engineering must meet the following requirements:

- Be in good academic standing
- Have no less than a C- in any Math, Science and Engineering coursework
- Have a minimum 2.0 GPA in all Math, Science and Engineering required coursework
- Be able to complete major within maximum allowable units
- Complete all the courses listed below, based on the total number of units earned, prior to submitting the major change request
- UCR transfer students interested in changing to a BCOE major must have been admissible to the major at point of entry, or must satisfy transfer admission and change of major requirements before earning 120 units
- If changing in the 90-119 units category student must have the ability to complete major within 5 years of entry as a Freshmen or 3 years after entry as a Transfer student
- Students who have earned 120 or more units are not eligible for a change of major in BCOE. NOTE: AP/IB units are excluded from maximum unit calculation

Completed 0 to less than 45 units Completion of ENGL 001A with C or better and completion of the following with at least 2.500 GPA:

- CHEM 001A or CHEM 01HA
- CHEM 01LA or CHEM 01HLA
- CHEM 001B or CHEM 01HB
- CHEM 01LB or CHEM 01HLB
- MATH 009A or MATH 09HA
- MATH 009B or MATH 09HB
- PHYS 040A or PHYS 040HA

Completed 45 to less than 90 units
Completion of ENGL 001A with C or better and completion of the following with at least 2.500 GPA:

- BIOL 005A or BIOL 05HA
- BIOL 05LA or BIOL 05HLA
- CHEM 001A or CHEM 01HA
- CHEM 01LA or CHEM 01HLA
- CHEM 001B or CHEM 01HB
- CHEM 01LB or CHEM/01HLB
- MATH 009A or MATH 09HA
- MATH 009B or MATH 09HB
- MATH 009C or MATH 09HC
- PHYS 040A or PHYS 040HA

Completed 90 to less than 120 units
Completion of ENGL 001A and ENGL 001B with C or better and completion of the following with at least 2.500:

- BIOL 005A or BIOL 05HA
- BIOL 05LA or BIOL 05HLA
- CHEM 001A or CHEM 01HA
- CHEM 01LA or CHEM 01HLA
- CHEM 001B or CHEM 01HB
- CHEM 01LB or CHEM 01HLB
- CHEM 001C or CHEM 01HC
- CHEM 01LC or CHEM 01HLC
- MATH 009A or MATH 09HA
- MATH 009B or MATH 09HB
- MATH 009C or MATH 09HC
- PHYS 040A or PHYS 040HA

University Requirements

See Undergraduate Studies section.

College Requirements

See The Marlan and Rosemary Bourns College of Engineering, Colleges and Programs section.

The Materials Science and Engineering major uses the following major requirements to satisfy the college's Natural Sciences and Mathematics breadth requirement.

1. One course in the biological sciences chosen from an approved list
2. CHEM 001A, CHEM 001LA
3. MATH 009A
4. PHYS 040A, PHYS 040B

Major Requirements

1. Lower-division requirements (75 units)
   a) CHEM 001A, CHEM 01LA, CHEM 001B, CHEM 01LB, CHEM 001C, CHEM 01LC
   b) CS 009A or CS 010A
   c) EE 005
   d) MATH 009A, MATH 009B, MATH 009C, MATH 010A, MATH 010B, MATH 046
   e) ME 010
   f) MSE 001, MSE 002L, MSE 003L, MSE 004L
   g) PHYS 040A, PHYS 040B, PHYS 040C
   h) CHEM 008A, CHEM 08LA
2. Upper-division requirements (76 units)
   a) BIEN 140A/CEE 140A
   b) CHE 100
   c) EE 138
   d) ENGR 180W
   e) ME 110, ME 114, ME 156
   f) MSE 134, MSE 135, MSE 160, MSE 161, MSE 175A, MSE 175B
   g) STAT 155
   h) Technical Electives (20 units):
      (1) Four (4) units of required technical electives, MSE 143
      (2) Sixteen (16) units chosen from BIEN/MSE 136, BIEN 140B/CEE 140B, CHE 105, CHE 161, EE 133, EE 136, EE 137, EE 139, EE 162, ME 153, MSE 142, MSE 148, MSE 155, MSE 156, MSE 197

Visit the Student Affairs Office in the College of Engineering or **student.engr.ucr.edu** for a sample program.

Graduate Program

The Department of Materials Science and Engineering offers programs leading to M.S. and Ph.D. degrees. Research focus areas currently include Materials Processing, Semiconductor Materials, Materials Analysis, Nanoscale Materials, Bioinspired Materials, Ceramic Materials, Magnetic Materials and Materials for Spintronics.

Admission

Applicants should have completed a program equivalent to UCR's B.S. in Materials Science and Engineering, obtained a B.S. in a related discipline and demonstrated particular interest/aptitude for Materials Science and Engineering, or demonstrate the required knowledge and proficiency in the following subjects

1. Fundamentals of Materials Science and Engineering (equivalent to MSE 001)
2. Fundamentals of Chemistry (equivalent to Chem 001A & Chem 001B & Chem 001C)
3. Fundamentals of Physics (equivalent to Phys 040A & Phys 040B and Phys 040C)
4. Fundamentals of Materials Synthesis or Processing (for instance, equivalent to Chem 112A)
5. Nanostructure Characterization or Materials Characterization (equivalent to MSE 160 or MSE 161).

Under special circumstances, students who have not completed all preparation course requirements may be admitted provided that the deficiencies are corrected within the first year of graduate study. Deficiencies limited to 12 units maximum. Courses taken for this purpose do not count towards an advanced degree.

All applicants whose native language is not English and who do not have a degree from an institution where English is the exclusive language of instruction must complete the Test of English as a Foreign Language (TOEFL) with a minimum score of 550 (paper-based), 213 (computer-based), or 80 (Internet-based). Beginning with the Fall 2011 application cycle,

UCR will accept scores from the Academic Modules of the International English Language Testing System IELTS, which is jointly managed by the British Council, IDP:IELTS Australia and the University of Cambridge ESOL Examinations. The exam must be taken within two years of the time prior to enrollment at UCR. The minimum acceptable scores are: overall band score of 7 with no individual section score less than 6. Please request an official Test Report Form (TRF) of your IELTS. Remember to order the TRF from the test center where you took the test and ask the administrator to send the official TRF to:

Graduate Admissions Office
Graduate Division
University Office Building
University of California, Riverside
Riverside, CA 92521 USA

For more information about registering for this exam or to locate the office of any test center, consult the IELTS website.

Applicants must meet the general admission requirements of the Riverside Division of the Academic Senate and the UCR Graduate Council as set forth in the UC Riverside Graduate Student Application.

Master of Science

The Program of Materials Science and Engineering offers the M.S. degree in Materials Science and Engineering. Students may obtain an M.S. degree in Materials Science and Engineering through one of two plans: 1) Thesis or 2) Comprehensive Examination.

Plan I (Thesis)

Students must complete 36 units of graduate or upper-division undergraduate course work, of which 24 must be graduate level units. Student must complete at least one course from 3 of the 5 areas of Materials Science and Engineering (MSE 201-209, 210-219, 220-229, 230-239, 240-249) as well as at least one unit of MSE 200 and at least five units of MSE 250. Students must enroll in MSE 200 the first time it is offered during their residency. At least two units of MSE 250-259 must be taken for a letter grade. Students can take a maximum of 12 units in Graduate Research and a maximum 6 units in Directed Studies. The course of study needs to be approved each quarter by the research advisor (when determined) and the MSE graduate advisor. The degree will be awarded when all these requirements are met and the thesis has been submitted successfully.

Plan II (Comprehensive Exam)

All students must complete 36 units of graduate or upper division undergraduate courses, of which 18 units must be graduate level. Student must complete at least one course from each of the 5 areas of Materials Science and Engineering (MSE 201-209, 210-219, 220-229, 230-39, 240-249) as well as at least one unit of MSE 200 and at least four units of MSE 250. At least one unit of MSE 250-259 must be taken for a letter grade. None may be in graduate research (MSE 297 or MSE 299). A maximum of 6 units may be in Directed Studies. Students must enroll in MSE 200 the first time it is offered during their residency. The course of study needs to be approved each quarter by the MSE graduate advisor.

Students will take a written comprehensive examination conducted jointly with the Ph.D. preliminary examination. The examination emphasizes the fundamental knowledge of the study area rather than the specifics covered in individual courses.

Students concurrently enrolled in a Ph.D. program in another department must have their course of study approved by the Graduate Advisor. Coursework used to complete requirements in a non-MSE Ph.D. program cannot be used towards the Master's degree in MSE. An Oral Comprehensive Examination that measures the student's breadth of knowledge in Materials Science and Engineering will be given after the appropriate course of study has been completed.

Normative Time to Degree

Six quarters (two years)

Doctoral Degree

The Program of Materials Science and Engineering offers the Ph.D. degree in Materials Science and Engineering.

Admission

In addition to the requirements set forth for a M.S. degree, applicants should demonstrate exceptional achievement that clearly indicates their ability to conduct Ph.D. level studies.

Course Work

There is no comprehensive course requirement for the Ph.D. degree; only a few courses are mandatory. The faculty recommends that the student take a minimum of 36 units of graduate or upper-division undergraduate course work covering all five areas of study in Materials Science and Engineering: Thermodynamic Foundation of Materials, Crystal Structure and Bonding, Materials Characterization Techniques, Functional Materials, and Materials Synthesis and Processing (MSE 201-MSE 209, MSE 210-MSE 219, MSE 220-MSE 229, MSE 230-MSE 239, MSE 240-MSE 249). Students must enroll in MSE 200 the first time it is offered during their residency. Students must enroll in MSE 250 during all quarters of residency and must obtain a letter grade in an MSE 250-MSE 259 course once during each academic year of residency except for the first one.

The courses may include graduate course work used for the M.S. degree. The course of study needs to be approved each quarter by the research advisor (when determined) and the MSE graduate advisor. Students may need to take considerably more than the courses indicated above to prepare for and conduct their Ph.D. research.

Preliminary Examination

The purpose of the preliminary examination is to screen candidates for continuation in the doctoral program. The examination is administered by the graduate program committee jointly with the M.S. comprehensive examination. Candidates must solve at least one problem in each of the five areas of study in Material Science and Engineering. Plan II M.S. candidates who took the combined M.S. comprehensive and Ph.D. preliminary examination and successfully passed at the Ph.D. level are given credit for having passed the Ph.D. preliminary examination.

Dissertation Proposal and Oral Qualifying Examination

After passing the preliminary examination at the Ph.D. level, doctoral candidates must prepare and submit a dissertation proposal to their qualifying examination committee at least one month before the qualifying examination. The format of the proposal is flexible, but the proposal should clearly indicate the proposed problem under study, demonstrate substantial knowledge of the topic and related issues, state the progress made towards a solution, and indicate the work remaining to be done. The new approaches and methods to be used in the research should also be discussed. An extensive bibliography for the problem under study should be attached to the proposal. Within one week after submission, the student is informed whether the proposal meets these standards and the student is permitted to proceed to the oral exam.

The oral qualifying examination focuses on the dissertation problem. It includes considerable depth in the student's area of specialization, as required for a successful completion of the dissertation. The examination is a three-hour session, which begins with the student's presentation of the dissertation topic and is followed with questions and suggestions by the doctoral committee.

Dissertation Examination and Defense

A doctoral dissertation should be an original and substantial contribution to knowledge in the student's major field. The dissertation must demonstrate the student's ability to carry out a program of independent advanced research and to report the results in accordance with standards observed in recognized scientific journals. When the doctoral committee determines that a suitable draft of the dissertation has been presented, a dissertation examination and defense for the student is scheduled. The defense consists of a public seminar followed by questions from the committee members and the audience.

Normative Time to Degree

12 quarters (15 quarters for students without an M.S. in Materials Science and Engineering)

Preparation for Careers in Teaching

All doctoral students are encouraged to serve as teaching assistants for at least three quarters during their graduate career. The program offers a Teaching Practicum in Materials Science and Engineering (MSE 302).

Dissertation Examination and Defense

Contact the Graduate Student Affairs Assistant at the Department of Materials Science and Engineering, (951) 827-3383, or visit mse.ucr.edu for information on graduate courses.

Lower-Division Courses

MSE 001 Fundamentals of Materials Science and Engineering 2 Lecture, 3 hours; discussion, 1 hour; laboratory, 1 hour. Prerequisite(s): none. An introduction of properties and applications of different types of materials essential for various areas of engineering. Explores the relationship between structure and properties as well as processing of the materials. Illustrates a wide range of properties required for different types of applications. Graded Satisfactory (S) or No Credit (NC).

MSE 002L General Materials Laboratory Spring 1 Laboratory, 3 hours. Prerequisite(s): MSE 001 with a grade of C- or better; restricted to major(s) Materials Science and Engineer; or consent of instructor. Provides hands-on laboratory experience in topics related to the Structure-Composition-Processing-Performance relationship of ceramics, electronic materials, metals, and polymers. Experiments cover mechanical testing and properties of different materials classes and introduce students to microscopic characterization techniques. Satisfactory(S) or No Credit(N/C) is not available.

MSE 003L General Materials Laboratory Fall 1 Laboratory, 3 hours. Prerequisite(s): MSE 001 with a grade of C- or better; restricted to major(s) Materials Science and Engineer; or consent of instructor. Provides hands-on laboratory experience in topics related to the Structure-Composition-Processing-Performance relationship of ceramics, electronic materials, metals, and polymers. Experiments cover materials processing and failure modes of different materials classes. Satisfactory(S) or No Credit(N/C) is not available.

MSE 004L General Materials Laboratory Winter 1 Laboratory, 3 hours. Prerequisite(s): MSE 001 with a grade of C- or better; restricted to major(s) Materials Science and Engineer; or consent of instructor. Provides hands-on laboratory experience in topics related to the Structure-Composition-Processing-Performance relationship of ceramics, electronic materials, metals, and polymers. Experiments cover electrical, thermal, optical, and magnetic properties. Introduces composites and the factors that affect its properties and mechanical performance. Satisfactory(S) or No Credit(N/C) is not available.

Upper-Division Courses

MSE 134 Microstructural Transformations in Materials 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ME 114 or consent of instructor. An introductory study of the fundamentals (thermodynamics and kinetics) controlling microstructural transformations in materials and their application to both liquid-solid and solid-solid transformations. Focuses on the important transformations that ultimately control the microstructures and properties of crystalline solids. Cross-listed with ME 134.

MSE 135 Introduction to Inorganic Material Synthesis 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MSE 001, CHE 100, ME 114, CHEM 008A; or consent of instructor. Introduction to the synthesis methods of modern materials. Topics include solid-state reactions, gas-phase and solution phase synthesis, templating methods, synthesis and modification of inorganic polymers, semiconductor thin-film deposition, and the growth of nanomaterials.

MSE 136 Tissue Engineering 4 Lecture, 3 hours; term paper, 3 hours. Prerequisite(s): BIOL 005B; CHEM 001C or CHEM 01HC; BIEN 140A or CEE 140A; restricted to class level standing of junior, or senior; or consent of instructor. Covers progress in cellular and molecular biology and engineering. Provides the basis for advancing tissue repair and regeneration with the goal of restoring compromised tissue functions. Presents methods for cell culture, tissue design and development, manipulation of the cell/tissue microenvironment, and current strategies for functional reconstruction of injured tissues. Cross-listed with BIEN 136.

MSE 142 Corrosion Science 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MSE 134; restricted to class level standing of senior; or consent of instructor. Introduces the principles of corrosion in metals and alloys. Discusses the relevant elements of electrochemistry, electrochemical corrosion, thermodynamics, and the kinetic aspects of corrosion. Includes projects that provide practical hands-on experience using state-of-the-art computational techniques in materials science. Credit is awarded for one of the following MSE 142 or MSE 233A.

MSE 143 Failure Analysis and Prevention 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ME 114 with a grade of C or better; restricted to class level standing of senior; or consent of instructor. Topics include failure modes due to overload, fatigue, fracture, and creep. Also addresses statistical analysis, probability of failure, quality assurance, and elements of fracture mechanics. Cross-listed with ME 157. Credit is awarded for one of the following ME 157, MSE 143, or MSE 233B.

MSE 148 Advanced Solidification Processing 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MSE 143 or ME 157; restricted to class level standing of senior; or consent of instructor. An overview of the fundamentals of solidification processing. Includes integrated interplay of heat flow, mass transport, and solid/liquid interfacial kinetics during discontinuous change of state from liquid to solid of single phase and polyphase materials. Cross-listed with ME 158. Credit is awarded for one of the following MSE 148, ME 158, ME 279, or MSE 248C.

MSE 155 Materials Science of the Solid State 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): EE 138. Explores at an advanced level the quantum mechanical behavior of electron motion and atom vibration in a periodic solid and their effect on the electronic and thermal properties of matter. The course discusses modern materials science research problems. Credit is awarded for one of the following MSE 155 or MSE 211.

MSE 156 Atomistic Modeling of Solid State Materials 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MSE 155; restricted to class level standing of senior; or consent of instructor. Introduces a basic understanding of computational methods in materials science. Emphasizes the fundamentals of density functional theory and its use in the solid-state context. Includes projects that provide practical hands-on experience using state-of-the-art computational techniques in materials science. Credit is awarded for one of the following MSE 156 or MSE 224.

MSE 160 Nanostructure Characterization Laboratory 4 Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): ME 114. Covers structure of materials at the nanoscale, including semiconductors, ceramics, metals, and carbon nanotubes. Explores relationships among morphology, properties, and processing. Addresses primary methods of characterization, including scanning electron microscopy, scanning probe microscopy, X-ray diffraction, and transmission electron microscopy. Also covers elementary discussions of X-ray, vibrational, and electron waves in solids and introductory diffraction theory.

MSE 161 Analytical Materials Characterization 4 Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): MSE 160. Analysis of the surfaces of materials via ion, electron, and photon spectroscopies. Covers Rutherford back scattering; secondary ion mass spectroscopy; electron energy loss spectroscopy; Auger electron spectroscopy; X-ray photoelectron spectroscopy; photoluminescence; extended X-ray absorption fine structure; Fourier transform infrared spectroscopy; Raman spectroscopy; sputtering; high-vacuum generation; and focused ion beam milling. Cross-listed with EE 161.

MSE 175A Senior Design 4 Lecture, 2 hours; discussion, 1 hour; practicum, 3 hours. Prerequisite(s): restricted to class level standing of senior; restricted to major(s) Materials Science and Engineer. Covers preparation of formal engineering reports and statistical analysis on series of problems illustrating methodology from various branches of applied MSE. Addresses the following design process elements; problem definition; generation specification; documentation; review process; prototype fabrication; testing and calibration; cost estimation; and federal guidelines. Term project and oral presentation required. Graded In-Progress (IP) until MSE 175A and MSE 175B are completed, at which time a final, letter grade is assigned.

MSE 175B Senior Design 4 Lecture, 3 hours, discussion, 1 hour; practicum, 6 hours. Prerequisite(s): MSE 175A; senior standing in Materials Science and Engineering. Covers preparation of formal engineering reports and statistical analysis on a series of problems illustrating methodology from various branches of applied materials science and engineering. Addresses the entire design process: design problem definition; generation of a design specification; documentation; design review process; prototype fabrication; testing and calibration; cost estimation; and federal guidelines. Requires a term project and oral presentation. Satisfactory (S) or No Credit (NC) grading is not available.

MSE 197 Research For Undergraduates 1 to 4 Laboratory, 3 to 12 hours. Prerequisite(s): sophomore or junior or senior standing in Materials Science and Engineering or consent of instructor. Research conducted under the supervision of a MSE faculty member on selected problems in materials science and engineering supporting the focus area of the

student. Course is repeatable to a maximum of 8 units; maximum of 4 units may count toward the technical elective requirement.

Graduate Courses

MSE 200 Graduate Studies in Materials Science and Engineering 4 Lecture, 4 hours. Prerequisite(s): Restricted to major(s) Materials Science and Engineer; graduate standing; or consent of instructor. Introduces the fundamentals of materials science and engineering including materials selection, processing, and manufacturing. Utilizes materials design, selection-based approach, and team activities to enhance learning and presentations. Provides information on how to research and survey literature and make technical presentations.

MSE 201 Thermodynamic Foundations of Materials 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): graduate standing in Materials Science and Engineering or consent of instructor. MSE 201 online section; enrollment in the Online Master-in-Science in Engineering program. Covers the laws of thermodynamics and fundamental equations for multi-component elastic solids, electromagnetic media, and equilibrium criteria. Describes applications to solution thermodynamics, point defects in solids, elastic effects, phase diagrams, transitions, and interfaces. Includes nucleation theory, kinetics (diffusion of heat, mass, and charge), and coupled flows.

MSE 204 Thermodynamics and Statistical Mechanics 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing; consent of instructor. Covers thermodynamics, statistical mechanics, ideal Bose systems, ideal Fermi systems, and bulk motion. Cross-listed with PHYS 212A.

MSE 205 Advanced Physical Chemistry: Thermodynamics 3 Lecture, 3 hours. Prerequisite(s): CHEM 110A and CHEM 110B with grades of "C" or better. Covers concepts in thermodynamics including fundamental equations, potentials, Maxwell relations, and stability criteria. Cross-listed with CHEM 201D.

MSE 207 Applied Quantum Mechanics 4 Lecture, 3 hours; research, 3 hours. Prerequisite(s): MATH 046, PHYS 040A; or consent of instructor. Covers topics in quantum mechanics including Schroedinger equation; operator formalism; harmonic oscillator; quantum wells; spin, bosons, and fermions; solids; perturbation theory; Wentzel-Kramers-Brillouin approximation; tunneling; tight-binding model; quantum measurements; quantum cryptography; and quantum computing. Cross-listed with EE 201.

MSE 208A Plasma-Aided Manufacturing and Materials Processing 4 Lecture, 4 hours. Prerequisite(s): graduate standing or consent of instructor. For ME 274/MSE 208A online section: enrollment in the Online Master-in-Science in Engineering program; graduate standing. Covers the fundamentals of gaseous plasmas and the physics of both equilibrium and non-equilibrium discharges. Explores the basic techniques for plasma diagnostics. Discusses the use of plasmas as a materials processing medium for a variety of manufacturing processes. Includes topics such as the processing of nanostructured materials using plasmas. Cross-listed with ME 274.

MSE 208B Nanoscale Heat Transfer and Energy Conversion 4 Lecture, 4 hours. Prerequisite(s): 2 of the following: MSE 207, ME 100A, ME 116A, EE 201, EE 202, MSE 217; or equivalents; graduate standing. Explores fundamental processes of energy transport and conversion at short length and time scales. Introduces classical and quantum-mechanical size effects on electrons, phonons, and photons. Topics include modes of energy storage, coupling between energy carriers, and electrical and thermal transport using the Boltzmann transport equation and/or kinetic theory. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with ME 244.

MSE 210 Crystal Structure and Bonding 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): graduate standing in Materials Science and Engineering or consent of instructor. MSE 210 online section; enrollment in the Online Master-in-Science in Engineering program . Covers regular and irregular arrays of points and spheres. Includes lattices (direct and reciprocal); crystallographic point and space groups; and atomic structures. Also addresses bonding in molecules and solids, ionic Pauling rules; and covalent and metallic bonding. Surveys the structure of elements, compounds, minerals, and polymers.

MSE 211 Materials Science of the Solid State 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing; or consent of instructor. Explores at an advanced level the quantum mechanical behavior of electron motion and atom vibration in a periodic solid and their effect on the electronic and thermal properties of matter. The course discusses modern materials science research problems. Credit is awarded for one of the following MSE 211 or MSE 155.

MSE 212 Quantum Electron Transport 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): EE 208 or MSE 227B; graduate standing; or consent of instructor. Covers the theory and methods used to model quantum electron transport in ultrascaled traditional semiconductor devices such as transistors, nanoscaled research semiconductor devices (such as quantum dots), and novel electronic material systems (such as carbon nanotubes and molecular wires.) May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with EE 212.

MSE 214 Condensed Matter Physics 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): PHYS 221C; graduate standing; or consent of instructor. Topics include classical and quantum theories of the electron gas; crystal and reciprocal lattices; crystal symmetries; electrons in a periodic potential; nearly free electrons; tight binding; band structure; metals, insulators and semiconductors; semiclassical dynamics; and semiclassical transport. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with PHYS 240A.

MSE 217 Fundamentals of Semiconductors and Nanostructures 4 Lecture, 3 hours; research, 3 hours. Prerequisite(s): EE 133, EE 201/MSE 207; or consent of instructor. Examines principles of semiconductor materials and nanostructures. Topics include periodic structures, electron and phonon transport, defects, optical properties, and radiative recombination. Also covers absorption and emission of radiation in nanostructures and nonlinear optics effects. Emphasizes properties of semiconductor superlattices, quantum wells, wires, and dots. Cross-listed with EE 202.

MSE 218 Imperfections in Solids 4 Lecture, 4 hours. Prerequisite(s): graduate standing; or consent of instructor. Covers fundamentals of crystal structures and crystal defects. Includes the generation of point defects, nucleation and propagation of dislocations, perfect and partial dislocations, twins, stacking faults, transformations, mechanics of semiconductor and metallic thin films, and multilayered structures. Cross-listed with ME 278.

MSE 220 Materials Characterization Techniques 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing in Materials Science and Engineering or consent of instructor. Covers basic principles of techniques used in the characterization of engineering materials by electron microscopy, diffraction, and spectroscopy. Provides analysis of defects responsible for materials properties. Addresses modern electrical, optical, and particle beam techniques for material characterization. Includes Hall Effect and Raman spectroscopy.

MSE 221 Electron Microscopy and Microanalysis 3 Lecture, 3 hours. Prerequisite(s): graduate standing in Materials Science & Engineering or consent of instructor. Introduces electron microscopy and microanalysis of inorganic solids including synthetic nanomaterials and minerals. Provides the underlying physical principles of electron microscopy and microanalysis; the strengths and limitations of the method; and the potential applications in characterization of morphology, structure, composition, and defects of inorganic materials and nanostructures. Optional, related laboratory courses are available: MSE 222L, MSE 223L.

MSE 222L Laboratory in Transmission Electron Microscopy 1 Laboratory, 2 hours; written work, 1 hour. Prerequisite(s): Concurrent or previous enrollment in MSE 221 or consent of instructor. Provides practical training in transmission electron microscopy and associated techniques including sample preparation.

MSE 223L Laboratory in Scanning Electron Microscopy 1 Laboratory, 2 hours; written work, 1 hour. Prerequisite(s): Concurrent or previous enrollment in MSE 221 or consent of instructor. Provides practical training in scanning electron microscopy and associated techniques including sample preparation.

MSE 224 Atomistic Modeling of Solid State Materials 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): EE 138 or MSE 211 or PHYS 150A; graduate standing; or consent of instructor. Introduces computational methods in materials science. Emphasizes fundamentals of density functional theory and its use in the solid-state context. Includes projects that provide practical hands-on experience. Students who present a seminar or submit a term paper receive a letter grade; other students receive a Satisfactory(S) or No Credit(NC) grade. Credit is awarded for one of the following MSE 224 or MSE 156.

MSE 225A Spectrometry in Organic Structure Analysis 3 Lecture, 3 hours. Prerequisite(s): graduate standing or consent of instructor. Utilizes modern spectroscopic techniques such as IR, mass spectrometry, and 1H and 13C NMR to determine the structure of complex organic molecules. Topics include advanced NMR techniques such as 2D NMR, NMR pulse sequences, diffusion NMR, and MRI. Cross-listed with CHEM 211D.

MSE 225B Advanced Analytical Chemistry: Optical Spectroscopy 3 Lecture, 3 hours. Prerequisite(s): CHEM 125W. Provides an overview of modern analytical optical spectroscopic techniques including theory, instrumentation, and applications. Cross-listed with CHEM 221B.

MSE 225C Introduction to Computational Quantum Chemistry 3 Lecture, 3 hours. Prerequisite(s): CHEM 113 or equivalent, graduate standing; or consent of instructor. Introduces computational techniques in quantum chemistry. Includes Hartree-Fock theory, Density Functional Theory, and electron correlation methods. Emphasizes practical applications in a research setting. Cross-listed with CHEM 206A.

MSE 226 Optical Methods in Biology, Chemistry, and Engineering 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): CHEM 109 or equivalent; graduate standing; consent of instructor. Covers the origin of fluorescence and other emission processes that modulate the characteristics of molecular emissions. Presents emission-based analytical and bioanalytical methods and techniques. Reviews state-of-the-art instrumentation, including their applicability, limitations, and source. Also provides interpretation and meaning of the measured signals as applied to biological systems. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Course is repeatable as content changes. Cross-listed with BIEN 245.

MSE 227A Nanoscale Characterization Techniques 4 Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): EE 201 or MSE 207; graduate standing; or consent of instructor. An in-depth study of nanoscale materials and device characterization techniques. Emphasizes atomic force microscopy (AFM) and scanning tunneling microscopy (STM). Includes semiconductor fabrication fundamentals; metrology requirements; in situ monitoring; interconnects and failure analysis; principles of AFM, STM, and scanning electron microscopy; X-ray methods; optical and infrared techniques; and electrical characterization. Cross-listed with EE 206.

MSE 227B Semiconductor Electronic and Optical Properties 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): PHYS 221B, may be taken concurrently or EE 202, may be taken concurrently or MSE 217, may be taken concurrently; graduate standing. Introduction to electronic bandstructure. Topics include electronic structure of semiconductors, graphene, localized orbital models, k dot p models, spin-orbit coupling, and optical generation of spin. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with EE 208.

MSE 229 Advanced Computation For Materials Design 4 Lecture, 4 hours. Prerequisite(s): graduate standing; or consent of instructor. Covers both desktop computing and high-performance computing (i.e., supercomputing resources) in the engineering sciences to understand and design materials using computational methods. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with CEE 240.

MSE 230 Functional Materials: Semiconductors 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): graduate standing in Materials Science and Engineering or consent of instructor. Covers semiconductor crystal growth techniques; purification; doping; radiation damage; annealing; metal-semiconductor interfaces; defects and impurities; and major electronic and optical methods for the analysis of semiconductors. Includes semiconductor device fabrication issues.

MSE 233A Corrosion Science 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MSE 233A online section; enrollment in the Online Master-in-Science in Engineering program. MSE 233A in-person section; graduate standing; or consent of instructor. Introduces the principles of electrochemistry and the essential elements of electrochemical corrosion, thermodynamics, and kinetic aspects of Material Sciences. Provides a fundamental understanding of the mechanisms of corrosion, testing, and protection as well as the influence of pH, dissolved gases, dissolved salts, temperature, and biological microorganisms. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Credit is awarded for one of the following MSE 233A or MSE 142.

MSE 233B Failure Analysis and Prevention 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MSE 233B online section; enrollment in the Online Master-in-Science in Engineering program. MSE 233B in-person section; graduate standing; or consent of instructor. Introduces the principles of failure analysis and prevention, emphasizing the influence of defects produced during casting, forming, and welding. Provides a fundamental understanding of overload failure modes, fatigue and fracture toughness, and creep. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Credit is awarded for one of the following MSE 233B, ME 157, or MSE 143.

MSE 234A Physics of Nanoscale Systems 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing; or consent of instructor. Introduction to fundamental quantum physics in nanoscale systems and low dimensional materials. Including synthesis of low-dimensional material systems; physics-based experimental approaches to nanotechnology; mesoscopic quantum transport of electrons; quantum phenomena involving spin; silicon nanoelectronics and beyond; and future electronics based on topological materials. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with PHYS 234.

MSE 234B Spintronics and Nanoscale Magnetism 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Provides an overview of contemporary issues in nanoscale magnetism and spin-dependent phenomena in solids, including the fundamentals of magnetism, magnetism in reduced dimensions, novel magnetic materials, spin-polarized transport, spin coherence in semiconductors, magnetization dynamics, and device applications. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with PHYS 235.

MSE 235 Solid State and Materials in Inorganic Chemistry 3 Lecture, 3 hours. Prerequisite(s): CHEM 231A/MSE 245B or consent of instructor. Covers the advanced synthesis, structure, bonding, and properties of inorganic materials. Cross-listed with CHEM 231C.

MSE 236 Nanomaterials For Regenerative Medicine 4 Lecture, 4 hours. Prerequisite(s): BIOL 005C, CHEM 001C (or CHEM 01HC), MSE 001, or equivalents; graduate standing or consent of instructor. Covers recent advances in nanomaterial synthesis, fabrication, and characterization. Focuses on the medical applications of nanomaterials and nanotechnologies. Addresses methods of synthesis of nanomaterials such as nanoparticles, nanotubes, and nanofibers. Includes critical design criteria and assessment methods for properties of nanomaterials to meet medical requirements. Cross-listed with BIEN 236.

MSE 237A Quantum Magnetism 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing; or consent of instructor. Introduces fundamental physical properties of magnetism and quantum behavior of magnetic materials for the understanding of modern magnetic devices. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with EE 220A.

MSE 237B Nanoscale Phonon Engineering 4 Lecture, 3 hours; research, 3 hours. Prerequisite(s): EE 202/MSE 217. Studies acoustic and optical phonons that affect electrical, thermal, and optical properties of materials. Focuses on the confinement-induced changes of phonon properties in nanostructures and their implications for performance of electronic, thermoelectric, and optoelectronic devices. Explores phonon

theory, Raman spectroscopy and other phonon characterization techniques, thermal conductivity, and related measurements. Cross-listed with EE 216.

MSE 237C Solid State Devices 4 Lecture, 3 hours; research, 3 hours. Prerequisite(s): EE 133 or consent of instructor. Covers electronic devices including p-n junctions, field-effect transistors, heterojunction bipolar transistors, and nanostructure devices. Explores electrical and optical properties of semiconductor heterostructures, superlattices, quantum wires, and dots, as well as devices based on these structures. Cross-listed with EE 203.

MSE 238 Introduction to Microelectromechanical Systems 4 Lecture, 4 hours. Prerequisite(s): ME 110, ME 114, or equivalents; for MSE 238 online section; enrollment in the Online Master-in-Science in Engineering program. An introduction to the design and fabrication of microelectromechanical systems (MEMS). Topics include micromachining processes; material properties; transduction; applications in mechanical, thermal, optical, radiation, and biological sensors and actuators; microfluidic devices; Bio-MEMS and applications; packaging and reliability concepts; and metrology techniques for MEMS. Cross-listed with ME 270.

MSE 239A Fundamentals of Heterogeneous Catalysis 4 Lecture, 3 hours; term paper, 3 hours. Prerequisite(s): CEE 204; graduate standing; or consent of instructor. Explores fundamental phenomenon of chemical reactivity on ground and excited state potential energy surfaces. Quantitatively relates electronic structure of catalytic materials to their chemical reactivity. Covers state-of-the-art experimental and theoretical approaches to studying catalytic reactivity. Provides a holistic understanding of catalysis at an atomic scale. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with CEE 222, and CHEM 222.

MSE 239B Synthesis and Characterization of Nanomaterials 3 Lecture, 3 hours. Prerequisite(s): graduate standing; or consent of instructor. Covers key concepts in synthesis and characterization techniques of nanoscale materials. Explores top down and bottom-up strategies for synthesizing low-dimensional nanomaterials and common techniques for nanoscale materials characterization. Also covers fundamental chemical principles of bonding, electronic structure, and atomic arrangements. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with CEE 224.

MSE 239C Electrochemical Engineering 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing; or consent of instructor. For CEE 235/MSE 239C online section; enrollment in the Online Master of Science in Engineering program; graduate standing. Explores the role of thermodynamics, charge transfer kinetics, and mass transfer on the behavior of electrochemical systems. Includes cell thermodynamics, Faradaic and non-Faradaic rate processes, ionic transport, nucleation, and growth theories. Covers applications to chemical sensors, batteries, corrosion, and thin film deposition. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with CEE 235.

MSE 240 Materials Synthesis and Processing 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Covers synthesis of functional materials and materials processing. Functional materials include semiconductors, metals, polymers, and nanoscaled-materials such as nanotubes and nanoparticles. Focuses on methods of semiconductor fabrication and their physical and chemical foundation.

MSE 245A Advanced Organic Reactions 3 Lecture, 3 hours. Prerequisite(s): graduate standing or consent of instructor. Covers modern organic reactions and reagents and their mechanistic pathways with emphasis on recent developments and practical organic chemistry. Cross-listed with CHEM 211E.

MSE 245B Structure and Bonding in Inorganic Chemistry 3 Lecture, 3 hours. Prerequisite(s): CHEM 150A, CHEM 150B. Covers advanced synthesis, structure, and bonding in inorganic, coordination, and organometallic chemistry. Cross-listed with CHEM 231A.

MSE 245C Nanoscience and Nanotechnology 3 Lecture, 3 hours. Prerequisite(s): graduate standing in Chemistry, Physics, Engineering, or a related subject or consent of instructor. Provides a condensed, interdisciplinary overview of selected fields of nanoscience and emerging nanotechnological applications. Focuses on applications relevant for the campus research community that are not based on electronic applications of silicon. Cross-listed with CHEM 203.

MSE 245D Interdisciplinary Overview of Current Issues in Semiconductor Processing 3 Lecture, 3 hours. Prerequisite(s): graduate standing in Chemistry, Physics, Engineering, or a related subject or consent of instructor. An interdisciplinary overview of present-day semiconductor processing. Introduces topics such as properties of semiconductors, cleanroom environment, epitaxy, ion implantation, etching, lithography, device architecture, testing, and fault detection. May offer field trips. Cross-listed with CHEM 208, and PHYS 202.

MSE 246 Cellular and Molecular Engineering 4 Lecture, 2 hours; discussion, 1 hours; practicum, 3 hours. Prerequisite(s): graduate standing or consent of instructor. BIEN 224 online section; enrollment in the Online Master-in-Science in Engineering program. Emphasizes biophysical and engineering concepts intrinsic to specific topics at the cellular and molecular level. Includes receptor-ligand dynamics in cell signaling and function; DNA replication and RNA processing; cellular and protein sorting; control of gene expression; membrane structure, transport and traffic; biological signal transduction; and mechanics of cell division. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with BIEN 224.

MSE 248A Nanoscale Science and Engineering 4 Lecture, 4 hours. Prerequisite(s): graduate standing or consent of instructor. For the MSE 248A/ME 272 online sections: enrollment in the Online Master-in-Science in Engineering program; graduate standing. An overview of the machinery and science of the nanometer scale. Topics include patterning of materials via scanning probe lithography; electron beam lithography; nanoimprinting; self-assembly; mechanical, electrical, magnetic, and chemical properties of nanoparticles, nanotubes, nanowires, and biomolecules (DNA, protein); self-assembled monolayers; and nanocomposites and synthetic macromolecules. Cross-listed with ME 272.

MSE 248B Mechanics and Physics of Materials 4 Lecture, 4 hours. Prerequisite(s): graduate standing; or consent of instructor. Course introduces students to topics related to Structure-Composition-Processing-Performance relationship of metallic materials. It will cover fundamentals of materials science, materials selection, processing and manufacturing. Materials design or selection-based approach and team activities will be utilized to enhance learning and presentation skills. Cross-listed with ME 266.

MSE 248C Advanced Solidification Processing 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MSE 134 or ME 134; graduate standing; or consent of instructor. An overview of the fundamentals of solidification processing. Includes integrated interplay of heat flow, mass transport, and solid/liquid (s/l) interfacial kinetics during discontinuous change of state from liquid to solid of single phase and polyphase materials. Cross-listed with ME 279. Credit is awarded for one of the following MSE 248C, ME 279, ME 158, or MSE 148.

MSE 250 Colloquium in Materials Science and Engineering 1 Colloquium,1 hour. Prerequisite(s): graduate standing in Materials Science and Engineering or consent of instructor. Presentations on current topics in Materials Science and Engineering presented by invited speakers, UCR faculty, and graduate students. Students who present a seminar receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable.

MSE 251 Topics in Materials Science and Engineering 1 Seminar, 1 hour. Prerequisite(s): graduate standing in Materials Science & Engineering or consent of instructor. Presentations on current topics in Materials Science and Engineering by special speakers, UCR faculty, and graduate students. Students who present a seminar receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable to a maximum of 21 units.

MSE 280 Special Topics in Biomaterials and Tissue Engineering 1 to 2 Seminar, 1 to 2 hours; term paper, 0 to 3 hours. Prerequisite(s): graduate standing or consent of instructor. Focuses on advanced biomaterials and tissue engineering for medical applications. Explores the design, processing, characterization, and evaluation of biomaterials. Examines current development in novel materials and recent advances in their applications in tissue engineering, drug delivery, gene therapy, cell therapy, medical devices, and implants. Students who present a seminar or submit a term paper receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable as content changes to a maximum of 30 units. Cross-listed with BIEN 272.

MSE 290 Directed Studies 1 to 6 Individual Study, 3 to 18 hours. Prerequisite(s): consent of instructor and graduate advisor. Individual study directed by a faculty member on selected topics in Materials Science and Engineering. Graded Satisfactory (S) or No Credit (NC). Course is repeatable to a maximum of 12 units

MSE 297 Directed Research 1 to 6 Research, 3 to 18 hours. Prerequisite(s): consent of instructor and graduate advisor. Research conducted under the supervision of a faculty member on selected topics in Materials Science and Engineering. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

MSE 298I Individual Internship in Materials Science & Engineering 1 to 12 Internship, 2 to 24 hours; written work, 1 to 12 hours. Prerequisite(s): graduate standing; consent of instructor. Provides the Materials Science & Engineering graduate student with career experience as an engineer in an industrial or national lab setting. Includes fieldwork with an approved professional individual or organization and academic work under the direction of a faculty member. Requires a final report. Graded Satisfactory (S) or No Credit (NC). Course is repeatable to a maximum of 16 units.

MSE 299 Research For the Thesis Or Dissertation 1 to 12 Research, 3 to 36 hours. Prerequisite(s): consent of instructor; graduate standing Research in materials science and engineering for the M.S. thesis or Ph.D. dissertation. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Professional Courses

MSE 302 Teaching Practicum 1 to 2 Consultation 1 To 2, Prerequisite(s): appointment as a teaching assistant in Materials Science and Engineering; consent of instructor and graduate advisor Topics include effective teaching methods, such as those involved in leading discussion sections and preparing and grading examinations, as well as student-instructor relations in lower- and upper-division Materials Science and Engineering courses. Required each quarter of teaching assistants and associates in Materials Science and Engineering. Graded Satisfactory (S) or No Credit (NC).

Mathematics

Subject abbreviation: MATH
College of Natural and Agricultural Sciences

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Department Office, 238 Skye Hall
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Professors

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Vyjayanthi Chari, Ph.D., *Distinguished Professor*
Wee Liang Gan, Ph.D.
Jacob Greenstein, Ph.D.
Michel L. Lapidus, Ph.D., *Distinguished Professor*
Yat Sun Poon, Ph.D.
Ziv Ran, Ph.D.
Rodolfo Torres, Ph.D., *Distinguished Professor*
Stefano Vidussi, Ph.D.
Frederick H. Wilhelm, Jr., Ph.D.
Bun Wong, Ph.D.
Feng Xu, Ph.D.
Qi S. Zhang, Ph.D.

Professor of Teaching

Estela Gavosto, Ph.D.

Professors Emeriti

John C. Baez, Ph.D., *F. Burton Jones Endowed Chair*
Richard E. Block, Ph.D.
Mei-Chu Chang, Ph.D.
John E. de Pillis, Ph.D.
Gerhard Gierz, Ph.D.
Zhuang-dan Guan, Ph.D.
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Frederic T. Metcalf, Ph.D.
Malempati M. Rao, Ph.D.
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David E. Rush, Ph.D.
Reinhard Schultz, Ph.D.
James D. Stafney, Ph.D.
Albert R. Stralka, Ph.D.

Associate Professors

Po-Ning Chen, Ph.D.
James Kelliher, Ph.D.
Carl Mautner, Ph. D.
Amir Moradifam, Ph.D.
Peter Samuelson, Ph.D.

Associate Professors of Teaching

Kevin Costello, Ph.D.
Sara Lapan, Ph.D.
David Weisbart, Ph.D.

Assistant Professors

Patricio Gallardo Candela, Ph.D.
Weitao Chen, Ph.D.
Heyrim Cho, Ph.D.
Yat Tin Chow, Ph.D.
Brian Collier, Ph.D.
Matthew Durham, Ph.D.
Jose Gonzalez, Ph.D.
Jia Gou, Ph.D.
Mykhailo Potomkin, Ph.D.
Qixuan Wang, Ph.D.
Yiwei Wang, Ph.D.
Agnieszka Zelerowicz, Ph.D.
Zhenghe Zhang, Ph.D.

Assistant Professor of Teaching

Sarah Yeakel, Ph.D.

**

Visiting Assistant Professors

Catharine Cannizzo, Ph.D.
Sayan Das, Ph.D.
Javier Gonzalez-Anaya, Ph.D.
Fazel Hadadifard, Ph.D.
Matthew Harper, Ph.D.
Tran Hung, Ph.D.
Ishan Ishan, Ph.D.
Jayan Mukherjee, Ph.D.
Mohammad Safdari, Ph.D.
Yang Yin, Ph.D.

Lecturer

Michael Curtis

Cooperating Faculty

Bai-Lian "Larry" Li, Ph.D. (Botany and Plant Sciences)

Academic Coordinator

Rob Lam

Major

The Department of Mathematics offers a B.A. and B.S. degree in programs that share a common, solid mathematical foundation but differ in their specializations in the pure and applied areas of mathematics. These programs can provide the basis for careers in mathematics itself or within the many scientific and business fields, which, in today's technological society, depend on a basic knowledge of mathematical methods.

The **B.A. in Mathematics**, following the liberal arts tradition, combines a broad coverage of the humanities and social sciences with a moderate amount of advanced mathematics in the major. It is selected most often either by students who intend to obtain a teaching credential with a specialty in mathematics or by students who wish to pursue graduate work in business or the social sciences.

The **B.S. in Mathematics** is more technical and contains a greater concentration of work in the major field. The Pure Mathematics program is directed toward students who may wish to pursue graduate work in pure mathematics. The General Applied Math option is directed toward students who may wish to pursue graduate work in applied mathematics.

The other Applied Mathematics programs, with options in Biology, Chemistry, Economics, Environmental Sciences, Physics, and Statistics, are designed to provide a rigorous training in mathematics together with a substantial background in the discipline of the option. The Computational Mathematics program is designed to prepare the student for professional work with computers and computer systems and for graduate work in computer science.

The **B.S. in Mathematics for Secondary Teachers** is intended for students planning to pursue a career in secondary education. Its courses cover the high school curriculum from an advanced perspective. Students are required to complete mathematics education and education courses in order to facilitate presence in the classroom early in their undergraduate career and to better prepare them for entry in a credential program.