MATERIALS SCIENCE AND ENGINEERING

Courses offered by the Department of Materials Science and Engineering are listed under the subject code MATSCI on the *Stanford Bulletin's* ExploreCourses (http://explorecourses.stanford.edu/browse) web site.

The Department of Materials Science and Engineering is concerned with the relation between the structure and properties of materials, factors that control the internal structure of solids, and processes for altering their structure and properties, particularly at the nanoscale.

Mission of the Undergraduate Program in Materials Science and Engineering

The mission of the undergraduate program in Materials Science and Engineering is to provide students with a strong foundation in materials science and engineering with emphasis on the fundamental scientific and engineering principles which underlie the knowledge and implementation of material structure, processing, properties, and performance of all classes of materials used in engineering systems. Courses in the program develop students' knowledge of modern materials science and engineering, teach them to apply this knowledge analytically to create effective and novel solutions to practical problems, and develop their communication skills and ability to work collaboratively. The program prepares students for careers in industry and for further study in graduate school.

The B.S. in Materials Science and Engineering provides training for the materials engineer and also preparatory training for graduate work in materials science. Capable undergraduates are encouraged to take at least one year of graduate study to extend their course work through the coterminal degree program which leads to an M.S. in Materials Science and Engineering. Coterminal degree programs are encouraged both for undergraduate majors in Materials Science and Engineering and for undergraduate majors in related disciplines.

Learning Outcomes (Undergraduate)

The department expects undergraduate majors in the program to be able to demonstrate the following learning outcomes. These learning outcomes are used in evaluating students and the department's undergraduate program. Students are expected to demonstrate the ability to:

1. Apply the knowledge of mathematics, science, and engineering to assess and synthesize scientific evidence, concepts, theories, and experimental data relating to the natural or physical world.
2. Extend students' knowledge of the natural or physical world beyond that obtained from secondary education by refining their powers of scientific observation, the essential process by which data is gained for subsequent analysis.
3. Design and conduct experiments, as well as understand and utilize the scientific method in formulating hypotheses and designing experiments to test hypotheses.
4. Function on multidisciplinary teams, while communicating effectively.
5. Identify, formulate, and solve engineering issues by applying conceptual thinking to solve certain problems, bypassing calculations or rote learning and relying on the fundamental meaning behind laws of nature.
6. Understand professional and ethical responsibility.
7. Understand the impact of engineering solutions in a global, economic, environmental, and societal context.
8. Demonstrate a working knowledge of contemporary issues.
9. Recognize the need for, and engage in, lifelong learning.
10. Apply the techniques, skills, and modern engineering tools necessary for engineering practice.
11. Transition from engineering concepts and theory to real engineering applications and understanding the distinction between scientific evidence and theory, inductive and deductive reasoning, and understanding the role of each in scientific inquiry.

Graduate Programs in Materials Science Engineering

Graduate programs lead to the degrees of Master of Science, Engineer, and Doctor of Philosophy. Graduate students can specialize in any of the areas of materials science and engineering.

Learning Outcomes (Graduate)

The purpose of the master's program is to provide students with the knowledge and skills necessary for a professional career or doctoral studies. This is done through course and laboratory work in solid state fundamentals and materials engineering, and further course work in a technical depth area which may include a master's Research Report. Typical depth areas include nanocharacterization, electronic and photonic materials, energy materials, nano and biomaterials.

The Ph.D. is conferred upon candidates who have demonstrated substantial scholarship and the ability to conduct independent research. Through course work and guided research, the program prepares students to make original contributions in Materials Science and Engineering and related fields.

Facilities

The department is located in the William F. Durand Building, with extensive facilities in the Jack A. McCullough Building and the Gordon and Betty Moore Materials Research Building. These buildings house offices for the chair, majority of the faculty, administrative and technical staff, graduate students as well as lecture and seminar rooms. The research facilities are equipped to conduct electrical measurements, mechanical testing of bulk and thin film materials, fracture and fatigue of advanced materials, metallography, optical, scanning, transmission electron microscopy, atomic force microscopy, UHV sputter deposition, vacuum annealing treatments, wet chemistry, and x-ray diffraction.

The McCullough/Moore Complex is also the home for the Center for Magnetic Nanotechnology (CMN (http://www.stanford.edu/group/nanomag_center)), Stanford Nanocharacterization Laboratory (SNL (http://www.stanford.edu/group/snl)) and Nanoscale Prototyping Laboratory (NPL (http://npl-web.stanford.edu); joint facility with Mechanical Engineering in Building 530). The department maintains a microcomputer cluster for its students, which is linked to the internet.

Depending on the needs of their programs, students and faculty also conduct research in a number of other departments and independent laboratories. Chief among these are the Stanford Nanofabrication Facility (SNF (http://snf.stanford.edu)), Geballe Laboratory for Advanced Materials (GLAM (http://stanford.edu/group/glam)), and Stanford Synchrotron Radiation Laboratory (SSRL (http://www-ssrl.slac.stanford.edu)).

The Stanford Nanofabrication Facility (SNF) is a laboratory joining government and industrially funded research on microelectronic materials, devices, and systems. It houses a 10,000 sq. ft., class 100 clean room for Si and GaAs integrated circuit fabrication, a large number of electronic test, materials analysis, and computer facilities, and office space for faculty, staff, and students. In addition, the Center for Integrated Systems (CIS (http://cis.stanford.edu)) provides start-up research funds and maintains a fellow-mentor program with industry.

Materials Science and Engineering (MSE/ MATSCI)

Completion of the undergraduate program in Materials Science and Engineering leads to the conferral of the Bachelor of Science in Materials Science and Engineering.

Mission of the Undergraduate Program in Materials Science and Engineering

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Requirements

		Units
Mathematics		
20 units minimum		
Select one of the following:		5
MATH 51	Linear Algebra, Multivariable Calculus, and Modern Applications	
CME 100/ ENGR 154	Vector Calculus for Engineers	
Select one of the following:		5
MATH 52	Integral Calculus of Several Variables	
CME 104/ ENGR 155B	Linear Algebra and Partial Differential Equations for Engineers	
Select one of the following:		5
MATH 53	Ordinary Differential Equations with Linear Algebra	
CME 102/ ENGR 155A	Ordinary Differential Equations for Engineers	
One additional course [1]		5
Science		
20 units minimum		
Must include a full year (15 units) of calculus-based physics or chemistry, with one quarter of study (5 units) in the other subject. [2]		20
Technology in Society		
One course minimum [3]		3-5
Engineering Fundamentals		
Two courses minimum		
Select one of the following:		4
ENGR 50	Introduction to Materials Science, Nanotechnology Emphasis [4]	
ENGR 50E	Introduction to Materials Science, Energy Emphasis [4]	
ENGR 50M	Introduction to Materials Science, Biomaterials Emphasis [4]	
At least one additional courses [4]		3-5
Department Requirements: MSE Fundamentals, Depth & Focus Areas		
Materials Science Fundamentals: All of the following courses:		16
MATSCI 142	Quantum Mechanics of Nanoscale Materials	
MATSCI 143	Materials Structure and Characterization	
MATSCI 144	Thermodynamic Evaluation of Green Energy Technologies	
MATSCI 145	Kinetics of Materials Synthesis	
Two of the following courses:		8
MATSCI 151	Microstructure and Mechanical Properties	
MATSCI 152	Electronic Materials Engineering	
MATSCI 156	Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution	
MATSCI 158	Soft Matter in Biomedical Devices, Microelectronics, and Everyday Life	
MATSCI 190	Organic and Biological Materials	
MATSCI 192	Materials Chemistry	
MATSCI 193	Atomic Arrangements in Solids	
MATSCI 194	Thermodynamics and Phase Equilibria	
MATSCI 195	Waves and Diffraction in Solids	
MATSCI 196	Defects in Crystalline Solids	
MATSCI 197	Rate Processes in Materials	
MATSCI 198	Mechanical Properties of Materials	
MATSCI 199	Electronic and Optical Properties of Solids	
Materials Science & Engineering Depth		16
Four laboratory courses for Sixteen units; Four units must be WIM		
MATSCI 161	Energy Materials Laboratory (WIM)	
MATSCI 164	Electronic and Photonic Materials and Devices Laboratory (WIM)	
MATSCI 160	Nanomaterials Laboratory	
MATSCI 162	X-Ray Diffraction Laboratory	
MATSCI 163	Mechanical Behavior Laboratory	
MATSCI 165	Nanoscale Materials Physics Computation Laboratory	
Focus Area Options [5, 6]		13
Total Units		103-107

1. See a list of approved math courses at ughb.stanford.edu (https://ughb.stanford.edu/courses-and-planning/approved-courses). AP/IB Credit (https://ughb.stanford.edu/petitions/ap-credit) may also be used to meet the 20 units minimum, but cannot replace the three required courses.
2. See a list of approved science courses at ughb.stanford.edu (https://ughb.stanford.edu/courses-and-planning/approved-courses). AP/IB Credit (https://ughb.stanford.edu/petitions/ap-credit)may also be used to meet the 20 units minimum in some cases; see the AP chart in the Bulletin or check with the School of Engineering in 135 Huang Engineering Center.
3. See a list of approved Technology in Society courses at ughb.stanford.edu (https://ughb.stanford.edu/courses-and-planning/approved-courses). Course chosen must be on the approved list the year taken.

4 See a list of approved Engineering Fundamentals Courses at ughb.stanford.edu (https://ughb.stanford.edu/courses-and-planning/approved-courses). If two of ENGR 50, ENGR 50E or ENGR 50M are taken, one may be used for the Engineering Fundamentals requirement and the other for the Materials Science Fundamentals requirement.

5 Focus Area Options: 13 units from one of the following Focus Area Options below. If the focus area contains only 12 units, but the combined unit total in major (SoE Fundamentals, MSE Fundamentals, MSE Depth and the Focus Area) is at 60 or more, it will be allowed and no petition is necessary.

6 The self-defined focus area option requires additional approval; program deviation forms for this option can be found on the MSE website (https://mse.stanford.edu/student-resources/forms/undergraduate).

7 A course may only be counted towards one requirement; it may not be double-counted. All courses taken for the major must be taken for a letter grade if that option is offered by the instructor. Minimum Combined GPA for all courses in Engineering Topics (Engineering Fundamentals and Depth courses) is 2.0.

Focus Area Options (Four courses for a minimum of 13 units; select from one of the ten Focus Areas.)

Bioengineering	
BIOE 80	Introduction to Bioengineering (Engineering Living Matter)
BIOE 220	Introduction to Imaging and Image-based Human Anatomy
BIOE 260	Tissue Engineering
BIOE 281	Biomechanics of Movement
BIOE 381	Orthopaedic Bioengineering
MATSCI 158	Soft Matter in Biomedical Devices, Microelectronics, and Everyday Life
MATSCI 190	Organic and Biological Materials
MATSCI 380	Nano-Biotechnology
MATSCI 381	Biomaterials in Regenerative Medicine
MATSCI 382	Biochips and Medical Imaging
Chemical Engineering	
CHEM 171	Physical Chemistry I
CHEMENG 130	Separation Processes
CHEMENG 140	Micro and Nanoscale Fabrication Engineering
CHEMENG 150	Biochemical Engineering
MATSCI 158	Soft Matter in Biomedical Devices, Microelectronics, and Everyday Life
Chemistry	
CHEM 151	Inorganic Chemistry I
CHEM 153	Inorganic Chemistry II
CHEM 171	Physical Chemistry I
CHEM 173	Physical Chemistry II
CHEM 175	Physical Chemistry III
CHEM 181	Biochemistry I
CHEM 183	Biochemistry II
CHEM 185	Biophysical Chemistry
Electronics & Photonics	
EE 101A	Circuits I
EE 101B	Circuits II
EE 102A	Signal Processing and Linear Systems I
EE 102B	Signal Processing and Linear Systems II
EE 116	Semiconductor Devices for Energy and Electronics
EE 134	Introduction to Photonics
EE 142	Engineering Electromagnetics (Formerly EE 141)
EE 155	Green Electronics
ME 210	Introduction to Mechatronics
MATSCI 343	Organic Semiconductors for Electronics and Photonics
MATSCI 346	Nanophotonics
Energy Technology	
EE 293B	Fundamentals of Energy Processes
EE 155	Green Electronics
CEE 107A	Understanding Energy
EE 293B	Fundamentals of Energy Processes
MATSCI 156	Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution
MATSCI 302	Solar Cells
MATSCI 303	Principles, Materials and Devices of Batteries
ME 260	Fuel Cell Science and Technology
ME 262	Physics of Wind Energy
Materials Characterization Techniques	
MATSCI 320	Nanocharacterization of Materials
MATSCI 321	Transmission Electron Microscopy
MATSCI 322	Transmission Electron Microscopy Laboratory
MATSCI 323	Thin Film and Interface Microanalysis
MATSCI 326	X-Ray Science and Techniques
CHEMENG 345	Fundamentals and Applications of Spectroscopy
BIO 232	Advanced Imaging Lab in Biophysics
APPPHYS 201	Electrons and Photons (PHOTON 201)
Mechanical Behavior & Design	
AA 240	Analysis of Structures
AA 256	Mechanics of Composites
MATSCI 198	Mechanical Properties of Materials
MATSCI 241	Mechanical Behavior of Nanomaterials
MATSCI 358	Fracture and Fatigue of Materials and Thin Film Structures
ME 80	Mechanics of Materials
or CEE 101A	Mechanics of Materials
ME 203	Design and Manufacturing
Nanoscience	
ENGR 240	Introduction to Micro and Nano Electromechanical Systems
MATSCI 241	Mechanical Behavior of Nanomaterials
MATSCI 316	Nanoscale Science, Engineering, and Technology
MATSCI 320	Nanocharacterization of Materials
MATSCI 346	Nanophotonics
MATSCI 347	Magnetic materials in nanotechnology, sensing, and energy
MATSCI 380	Nano-Biotechnology
Physics	
PHYSICS 70	Foundations of Modern Physics
PHYSICS 110	Advanced Mechanics
PHYSICS 120	Intermediate Electricity and Magnetism I

PHYSICS 121	Intermediate Electricity and Magnetism II
PHYSICS 130	Quantum Mechanics I
PHYSICS 131	Quantum Mechanics II
PHYSICS 134	Advanced Topics in Quantum Mechanics
PHYSICS 170	Thermodynamics, Kinetic Theory, and Statistical Mechanics I
PHYSICS 171	Thermodynamics, Kinetic Theory, and Statistical Mechanics II
PHYSICS 172	Solid State Physics
Self-Defined Option	
Petition for a self-defined cohesive program. [7]	

For additional information and sample programs see the Handbook for Undergraduate Engineering Programs (http://ughb.stanford.edu).

Honors Program

The Materials Science and Engineering honors program offers an opportunity for undergraduate Materials Science and Engineering majors with a GPA of 3.5 or higher to pursue independent research at an advanced level, supported by a faculty advisor and graduate student mentors. The main requirements are as follows:

1. Application to the honors program (must be pre-approved by faculty advisor)
2. Enrollment in MATSCI 150 and participation in an independent research project over three sequential full quarters
3. Completion of a faculty-approved thesis
4. Participation in either the yearly Materials Science and Engineering Research Symposium OR an alternate, approved public oral/poster presentation

Since this requires three full quarters of research in addition to a final written thesis and presentation following completion of the work, students must apply to the program no less than four quarters prior to their planned graduation date. Materials Science and Engineering majors pursuing a typical four-year graduation timeline should meet with student services no later than the Winter quarter of their junior year to receive information on the application process.

All requirements for the honors program are in addition to the normal undergraduate program requirements.

To apply to the MATSCI Honors program:

- Have an overall GPA of 3.5 or higher (as calculated on the unofficial transcript) prior to application.
- Seek out a MATSCI faculty advisor and agree on a proposed research topic. Primary honors advisor must be a member of the School of Engineering academic council.
- Compose a brief (less than 1 page) summary of proposed research, including a proposed title, and submit along with unofficial transcript and signed faculty endorsement.
- Submit application at least four quarters prior to planned graduation.

To complete the MATSCI Honors program:

- Overall GPA of 3.5 or higher (as calculated on the unofficial transcript) at graduation
- Complete at least three quarters of research with a minimum of 9 units of MATSCI 150 for a letter grade (students may petition out of unit requirement with faculty advisor approval). All quarters must focus on the same topic. Maintain the same faculty advisor throughout, if possible.
- Present either a poster or oral presentation of thesis work in the Materials Science and Engineering Research Symposium held during Spring Quarter or, at the faculty advisor's discretion, in a comparable public event.
- Submit final drafts of an Honors Thesis to Dr. Ryan Brock and to the faculty advisor at least one quarter prior to graduation. Both must approve the thesis by completing a Signature Page and returning it to student services.
- Submit to MATSCI student services one copy of the honors thesis in electronic form at the same time as the final hard copy. Submit one copy of the thesis, with the signature page indicating approval of both readers (primary advisor and Dr. Brock), to the School of Engineering's Office of Student Affairs in 135 Huang.

Materials Science and Engineering (MATSCI) Minor

A minor in Materials Science and Engineering allows interested students to explore the role of materials in modern technology and to gain an understanding of the fundamental processes that govern materials behavior.

The following courses fulfill the minor requirements:

		Units
Engineering Fundamentals		
Select one of the following:		4
ENGR 50	Introduction to Materials Science, Nanotechnology Emphasis	
ENGR 50E	Introduction to Materials Science, Energy Emphasis	
ENGR 50M	Introduction to Materials Science, Biomaterials Emphasis	
Materials Science Fundamentals and Engineering Depth		
Select six of the following:		24
MATSCI 142	Quantum Mechanics of Nanoscale Materials	
MATSCI 143	Materials Structure and Characterization	
MATSCI 144	Thermodynamic Evaluation of Green Energy Technologies	
MATSCI 145	Kinetics of Materials Synthesis	
MATSCI 151	Microstructure and Mechanical Properties	
MATSCI 152	Electronic Materials Engineering	
MATSCI 156	Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution	
MATSCI 158	Soft Matter in Biomedical Devices, Microelectronics, and Everyday Life	
MATSCI 160	Nanomaterials Laboratory	
MATSCI 161	Energy Materials Laboratory	
MATSCI 162	X-Ray Diffraction Laboratory	
MATSCI 163	Mechanical Behavior Laboratory	
MATSCI 164	Electronic and Photonic Materials and Devices Laboratory	
MATSCI 165	Nanoscale Materials Physics Computation Laboratory	
MATSCI 190	Organic and Biological Materials	
MATSCI 192	Materials Chemistry	
MATSCI 193	Atomic Arrangements in Solids	
MATSCI 194	Thermodynamics and Phase Equilibria	
MATSCI 195	Waves and Diffraction in Solids	
MATSCI 196	Defects in Crystalline Solids	
MATSCI 197	Rate Processes in Materials	
MATSCI 198	Mechanical Properties of Materials	

MATSCI 199	Electronic and Optical Properties of Solids	
Total Units		28

Master of Science in Materials Science Engineering

The University's basic requirements for the M.S. degree are discussed in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)" section of this bulletin. The following are specific departmental requirements.

The Department of Materials Science and Engineering requires a minimum of 45 units for a master's degree to be taken in residence at Stanford. A Master's Program Proposal (http://studentaffairs.stanford.edu/sites/default/files/registrar/files/progpropma.pdf) form should be filled out, signed by the student's academic adviser, and submitted to the department's student services manager by the end of the student's first quarter of study. Final revisions to the master's program proposal must be submitted no later than one academic quarter prior to the quarter of expected degree conferral. Stanford Materials Science undergraduates who are pursuing or who plan to pursue a Coterminal M.S. degree may have more flexibility in their programs and should consult with their academic advisers regarding appropriate core course and elective choices.

Degree requirements are as follows:

1. A minimum of 30 units of Materials Science and Engineering (MATSCI) course work, including core and lab courses specified below, all taken for a letter grade. Research units, one-unit seminars, MATSCI 299 Practical Training and courses in other departments (i.e., where students cannot enroll in a class with a MATSCI subject code) cannot be counted for this requirement.
2. Of these 30 units Materials Science requirements, students must include a or b.
   a. three classes from MATSCI 201-210 core courses and three MATSCI 171, 172, 173, 174, 175 laboratory courses. One laboratory requirement may be fulfilled by taking a lab course from another engineering department.

		Units
Select three of the following core courses:		
MATSCI 201	Applied Quantum Mechanics I	3
MATSCI 202	Materials Chemistry	3
MATSCI 203	Atomic Arrangements in Solids	3
MATSCI 204	Thermodynamics and Phase Equilibria	3
MATSCI 205	Waves and Diffraction in Solids	3
MATSCI 206	Defects in Crystalline Solids	3
MATSCI 207	Rate Processes in Materials	3
MATSCI 208	Mechanical Properties of Materials	3
MATSCI 209	Electronic and Optical Properties of Solids	3
MATSCI 210	Organic and Biological Materials	3
Total core course units		9
Select three of the following lab courses:		
MATSCI 171	Energy Materials Laboratory	3
MATSCI 172	X-Ray Diffraction Laboratory	3
MATSCI 173	Mechanical Behavior Laboratory	3
MATSCI 174	Electronic and Photonic Materials and Devices Laboratory	3
MATSCI 175	Nanoscale Materials Physics Computation Laboratory	3
One laboratory requirment may be fulfilled by taking lab courses from another engineering dept.		
Total lab course units		9
TOTAL		18

   b. four classes from MATSCI 201-210 core courses and two MATSCI 171, 172, 173, 174, 175 laboratory courses. One laboratory requirement may be fulfilled by taking a lab course from another engineering department.

		Units
Select four of the following core courses:		
MATSCI 201	Applied Quantum Mechanics I	3
MATSCI 202	Materials Chemistry	3
MATSCI 203	Atomic Arrangements in Solids	3
MATSCI 204	Thermodynamics and Phase Equilibria	3
MATSCI 205	Waves and Diffraction in Solids	3
MATSCI 206	Defects in Crystalline Solids	3
MATSCI 207	Rate Processes in Materials	3
MATSCI 208	Mechanical Properties of Materials	3
MATSCI 209	Electronic and Optical Properties of Solids	3
MATSCI 210	Organic and Biological Materials	3
Total core course units		12
Select two of the following lab courses:		
MATSCI 171	Energy Materials Laboratory	3
MATSCI 172	X-Ray Diffraction Laboratory	3
MATSCI 173	Mechanical Behavior Laboratory	3
MATSCI 174	Electronic and Photonic Materials and Devices Laboratory	3
MATSCI 175	Nanoscale Materials Physics Computation Laboratory	3
One laboratory requirment may be fulfilled by taking lab courses from another engineering dept.		
Total lab course units		6
TOTAL		18

3. 15 units of approved course electives to result in a technically cohesive program. Of the 15 units of elective courses:
   a. 12 units must be taken for a letter grade (except for those submitting a M.S. thesis report).
   b. a maximum of three units may be seminars.
   c. if writing a master's thesis report, a minimum of 6 and a maximum of 15 units of MATSCI 200 Master's Research may be counted. Master's research units may be counted only if writing a M.S. thesis report. The final version of the thesis report must be signed off by two faculty and submitted to student services manager by last day of classes of the graduation quarter. See student services manager for details and approval.
   d. a maximum of three units may be undergraduate units, but not courses below the 100 level offering.
   e. a maximum of five units may be used for a foreign language course (not including any remedial English or courses in the student's native language if other than English). Students must plan to enroll in an upper level designation of a foreign language course offering.
   f. the combination of seminar, undergraduate, and language units may not exceed six units total.
   g. the combination of research, seminar, undergraduate, and language units may not exceed 15 units total.
   h. activity units may not be counted toward M.S. degree.
4. A minimum grade point average (GPA) of 2.75 for degree course work.

All proposed degree programs are subject to approval by student's academic adviser, and department's student services manager, who has responsibility for assuring that each proposal is a technically cohesive program. The M.S. degree is expected to be completed within two years during the University's candidacy period for completion of a master's degree.

Master's Thesis Report

Students wishing to take this option must consult with a MATSCI faculty member initially. Out of the 45 units M.S. degree requirements, 6-15 units may be taken in Materials Science Master's research by enrolling in MATSCI 200. Students using 15 units of research toward the degree must participate in a more complex and demanding research project than those using lesser units.

The M.S. thesis report must be approved and signed off by two faculty members. In general, one is student's research adviser, if adviser is a non MATSCI faculty member, a second MATSCI faculty is required to sign off on the thesis report. Consult with student services manager about faculty criteria, and requirements. Three copies of M.S. thesis report in final format should be submitted to two faculty advisers, and the department. The report is not an official University thesis but is intended to demonstrate to the department and faculty student's ability to conduct and report a directed research.

As a general guide line, a 6-9 units of master's research is a normal load for most students. The report should reflect the number of units taken. For instance, 3-4 laboratory reports are required for a 3-unit laboratory course. Accordingly, the level expected for 9 units of research would be at least equivalent to three such courses.

Students are advised to submit their thesis draft to faculty adviser readers by the end of fifth week of the quarter in which the units are to be assigned to allow time for faculty comments and revisions. A collated final version of the thesis report should be submitted to faculty and student services manager by last day of classes of student's graduation quarter. The appropriate grade for satisfactory progress in the research project prior to submission of the final report is 'N' (continuing); the 'S' (Satisfactory) final grade is given only when the report is fully approved and signed off by both faculty members.

In cases where students decide to pursue research after the initial program submission deadline, they should submit a revised M.S. Program Proposal at least two quarters before the degree is granted. The total combined units of Materials Science research units, seminars, language courses, and undergraduate courses cannot exceed 15. If a master's thesis report is not submitted, units in MATSCI 200 Master's Research cannot be applied to the department's requirement of 45 units for the conferral of the master's degree.

Honors Cooperative Program

Some of the department's graduate students participate in the Honors Cooperative Program (HCP), which makes it possible for academically qualified engineers and scientists in industry to be part-time graduate students in Materials Science while continuing professional employment. Prospective HCP students follow the same admissions process and must meet the same admissions requirements as full-time graduate students. For information regarding the Honors Cooperative Program, see Graduate Programs in the "School of Engineering (http://exploredegrees.stanford.edu/schoolofengineering)" section of this bulletin.

Petition Process for Transfer from M.S. to Ph.D. Degree Program

Students admitted to graduate programs are admitted specifically into either the terminal M.S. or the Ph.D. program. A student admitted to the terminal M.S. program should not assume admission to the Ph.D. program. Admission to the Ph.D. program is required for a student to be eligible to work towards the Ph.D. degree.

A student in the terminal M.S. program may petition to be admitted to the Ph.D. program by filing an M.S. to Ph.D petition form. Petition must include a one-page statement of purpose explaining why the student wishes to transfer to the Ph.D. program, most recent unofficial transcript, and two letters of recommendation from members of the Stanford faculty, including one from the student's prospective research adviser and at least one from a Materials Science faculty member belonging to the Academic Council. The M.S. to Ph.D. petition to transfer should be submitted to the student services manager by June of the first year in the M.S. program. Students who wish to submit a petition to the Ph.D. degree, should plan to complete at least six of the MATSCI 200 series (including MATSCI 203 Atomic Arrangements in Solids, MATSCI 204 Thermodynamics and Phase Equilibria, MATSCI 207 Rate Processes in Materials) core courses during their first year of admission. A grade point average (GPA) of 3.5 or better in the core courses is requirement.

Transferring to the Ph.D. program is a competitive process and only highly qualified M.S. students may be admitted. Student's original application to the graduate program as well as the materials provided for the transfer petition are reviewed. Students must adhere to requirements for the terminal M.S. degree, and plan to confer the M.S. degree in the event that the Ph.D. petition to transfer is not approved.

Coterminal Master of Science Program in Materials Science and Engineering

Stanford undergraduates who wish to continue their studies for the Master of Science degree in Materials Science and Engineering through the Coterminal program may apply for admission after they have earned 120 units toward graduation (UTG) as shown on the undergraduate unofficial transcript. Applicants must submit their application no later than eight weeks before the start of the proposed admit quarter. The application must give evidence that student possesses a potential for strong academic performance at the graduate level. Scores from the Graduate Record Examination (GRE) General Test must be reported before action can be taken on an application.

Materials science is a highly integrated and interdisciplinary subject, therefore students of any engineering or science undergraduate major are encouraged to apply.

Information and other requirements pertaining to the Coterminal program in Materials Science and Engineering may be obtained from the department's student services manager.

University Coterminal Requirements

Coterminal master's degree candidates are expected to complete all master's degree requirements as described in this bulletin. University requirements for the coterminal master's degree are described in the "Coterminal Master's Program (http://exploredegrees.stanford.edu/cotermdegrees)" section. University requirements for the master's degree are described in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees/#masterstext)" section of this bulletin.

After accepting admission to this coterminal master's degree program, students may request transfer of courses from the undergraduate to the graduate career to satisfy requirements for the master's degree. Transfer of courses to the graduate career requires review and approval of both the undergraduate and graduate programs on a case by case basis.

In this master's program, courses taken during or after the first quarter of the sophomore year are eligible for consideration for transfer to the graduate career; the timing of the first graduate quarter is not a factor. No courses taken prior to the first quarter of the sophomore year may be used to meet master's degree requirements.

Course transfers are not possible after the bachelor's degree has been conferred.

The University requires that the graduate adviser be assigned in the student's first graduate quarter even though the undergraduate career may still be open. The University also requires that the Master's Degree Program Proposal be completed by the student and approved by the department by the end of the student's first graduate quarter.

Engineer in Materials Science Engineering

The University's basic requirements for the degree of Engineer are outlined in the "Graduate Degrees" section of this bulletin.

A student wishing to enter the Engineer program must have completed the requirements of the M.S. in Materials Science and Engineering, and must file a petition requesting admission to the program, stating the type of research to be done and the proposed supervising professor. Once approved, the Application for Candidacy must be submitted to the department's student services manager by the end of the second quarter in the Engineer program. Final changes in the Application for Candidacy form must be submitted no later than one academic quarter prior to degree conferral.

The 90-unit program must include 9 units of graduate courses in Materials Science with a MATSCI subject code (no research units, seminars, colloquia, and MATSCI 400 Participation in Materials Science Teaching, Participation in Teaching) beyond the requirements for the M.S. degree, and additional research or other units to meet the 90-unit University minimum requirement. A grade point average (GPA) of 3.0 must be maintained for all degree course work taken at Stanford.

The Engineer thesis must be approved and signed off by two Academic Council faculty members, one must be a MATSCI faculty member.

Doctor of Philosophy in Materials Science Engineering

The University's basic requirements for the Ph.D. degree are outlined in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)" section of this bulletin.

The Ph.D. degree is awarded after the completion of a minimum of 135 units of graduate work as well as satisfactory completion of any additional University requirements. Degree requirements for the department are as follows:

		Units
Core Courses [1]		30
EE 222	Applied Quantum Mechanics I	
MATSCI 202	Materials Chemistry	
MATSCI 203	Atomic Arrangements in Solids	
MATSCI 204	Thermodynamics and Phase Equilibria	
MATSCI 205	Waves and Diffraction in Solids	
MATSCI 206	Defects in Crystalline Solids	
MATSCI 207	Rate Processes in Materials	
MATSCI 208	Mechanical Properties of Materials	
MATSCI 209	Electronic and Optical Properties of Solids	
MATSCI 210	Organic and Biological Materials	
Five Elective Graduate Technical Courses [2]		15
Materials Science Colloquia [3]		3
MATSCI 230	Materials Science Colloquium (Autumn 2014)	
MATSCI 230	Materials Science Colloquium (Winter 2015)	
MATSCI 230	Materials Science Colloquium (Spring 2015)	
Research & Electives		87
75 Units of MATSCI 300: Ph.D. Research		
12 Units of Electives [4]		

1 At least six of these courses must be taken during the first year (including MATSCI 203 (http://exploredegrees.stanford.edu/schoolofengineering/materialsscienceandengineering) Atomic Arrangements in Solids, MATSCI 204 (http://exploredegrees.stanford.edu/schoolofengineering/materialsscienceandengineering) Thermodynamics and Phase Equilibria, and MATSCI 207 (http://exploredegrees.stanford.edu/schoolofengineering/materialsscienceandengineering) Rate Processes in Materials) . All core courses must be completed for a letter grade, and taken during the first two years in the program.

2 Elective technical courses must be in areas related directly to student's research interest in Materials Science and Engineering, and may not include MATSCI 230 (http://exploredegrees.stanford.edu/schoolofengineering/materialsscienceandengineering) Materials Science Colloquium, MATSCI 299 (http://exploredegrees.stanford.edu/schoolofengineering/materialsscienceandengineering) Practical Training, MATSCI 300 (http://exploredegrees.stanford.edu/schoolofengineering/materialsscienceandengineering) Ph.D. Research or MATSCI 400 (http://exploredegrees.stanford.edu/schoolofengineering/materialsscienceandengineering) Participation in Materials Science Teaching. All courses must be completed for a letter grade.

3 Materials Science & Engineering Ph.D. students are required to take MATSCI 230 (http://exploredegrees.stanford.edu/schoolofengineering/materialsscienceandengineering) Materials Science Colloquium during each quarter of their first year. Attendance is required, roll is taken, and more than two absences results to an automatic "No Pass" grade.

4 May include other engineering courses, or MATSCI 400 (http://exploredegrees.stanford.edu/schoolofengineering/materialsscienceandengineering) Participation in Materials Science Teaching or a maximum of 3 units MATSCI 299 (http://exploredegrees.stanford.edu/schoolofengineering/materialsscienceandengineering) Practical Training

- Students must consult with their academic adviser on Ph.D. course selection planning. For students with a non-MATSCI research adviser, the MATSCI academic/co-adviser must also approve the list of proposed courses. Any proposed deviations from the requirements can only be considered by petition.
- Ph.D. students are required to apply for and have conferred a MATSCI M.S. degree normally by the end of their third year of studies. A Graduate Program Authorization Petition (in Axess) and an M.S. Program Proposal (http://studentaffairs.stanford.edu/sites/default/files/registrar/files/progpropma.pdf) must be submitted after taking the Ph.D. qualifying examination.
- A departmental oral qualifying examination must be passed by the end of January of the second year. A grade point average (GPA) of 3.5 in core courses MATSCI 201-210 is required for admission to the Ph.D. qualifying examination. Students who have passed the Ph.D. qualifying examination are required to complete the Application for Candidacy to the Ph.D.degree by June of the second year after passing the qualifying examination. Final changes in the Application for Candidacy form must be submitted no later than one academic quarter prior to the TGR status.
- Maintain a cumulative GPA of 3.0 in all courses taken at Stanford.
- Students must present the results of their research dissertation at the University Ph.D. oral defense examination.
- Current students subject to either this set of requirements or a prior set must obtain the approval of their adviser before filing a revised program sheet, and should as far as possible adhere to the intent of the new requirements.

- Students may refer the list of "Advanced Specialty Courses and Cognate Courses" provided below as guidelines for their selection of technical elective units. As noted above, academic adviser approval is required.
- At least 90 units must be taken in residence at Stanford. Students entering with an M.S. degree in Materials Science from another university may request to transfer up to 45 units of equivalent work toward the total of 135 Ph.D. degree requirement units.
- Students may propose a petition for exemption from a required core course if they have taken a similar course in the past. To petition, a student must consult and obtain academic and/or research adviser approval, and consent of the instructor of the proposed core course. To assess a student's level of knowledge, the instructor may provide an oral or written examination on the subject matter. The student must pass the examination in order to be exempt from core course requirement. If the petition is approved, the student is required to complete the waived number of units by taking other relevant upper level MATSCI courses.

Advanced Specialty Courses

		Units
Biomaterials		
CHEMENG 310	Microhydrodynamics	
CHEMENG 355	Advanced Biochemical Engineering	
ME 381	Orthopaedic Bioengineering	
ME 457	Fluid Flow in Microdevices	
MATSCI 380	Nano-Biotechnology	
MATSCI 381	Biomaterials in Regenerative Medicine	
MATSCI 382	Biochips and Medical Imaging	
Electronic Materials Processing		
EE 212	Integrated Circuit Fabrication Processes	
EE 216	Principles and Models of Semiconductor Devices	
EE 311	Advanced Integrated Circuits Technology	
EE 316	Advanced VLSI Devices	
EE 312	Integrated Circuit Fabrication Laboratory	
MATSCI 312	New Methods in Thin Film Synthesis	
Materials Characterization		
CHEMENG 345	Fundamentals and Applications of Spectroscopy	
EE 329	The Electronic Structure of Surfaces and Interfaces	
MATSCI 312	New Methods in Thin Film Synthesis	
MATSCI 320	Nanocharacterization of Materials	
MATSCI 321	Transmission Electron Microscopy	
MATSCI 322	Transmission Electron Microscopy Laboratory	
MATSCI 323	Thin Film and Interface Microanalysis	
MATSCI 326	X-Ray Science and Techniques	
Mechanical Behavior of Solids		
AA 252	Techniques of Failure Analysis	
AA 256	Mechanics of Composites	
MATSCI 251	Microstructure and Mechanical Properties	
MATSCI 353	Mechanical Properties of Thin Films	
MATSCI 358	Fracture and Fatigue of Materials and Thin Film Structures	
ME 335A	Finite Element Analysis	
ME 335B	Finite Element Analysis	
ME 335C	Finite Element Analysis	
ME 340	Mechanics - Elasticity and Inelasticity	
ME 345	Fatigue Design and Analysis	
Physics of Solids and Computation		
APPPHYS 272	Solid State Physics	
APPPHYS 273	Solid State Physics II	
EE 222	Applied Quantum Mechanics I	
EE 223	Applied Quantum Mechanics II	
EE 228	Basic Physics for Solid State Electronics	
EE 327	Properties of Semiconductor Materials	
EE 328		
EE 329	The Electronic Structure of Surfaces and Interfaces	
MATSCI 331	Atom-based computational methods for materials	
MATSCI 343	Organic Semiconductors for Electronics and Photonics	
MATSCI 347	Magnetic materials in nanotechnology, sensing, and energy	
Soft Materials		
CHEMENG 310	Microhydrodynamics	
MATSCI 343	Organic Semiconductors for Electronics and Photonics	
ME 455	Complex Fluids and Non-Newtonian Flows	

Ph.D. Minor in Materials Science and Engineering

The University's basic requirements for the Ph.D. minor are outlined in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees/#doctoraltext)" section of this bulletin. A minor requires 20 units of graduate work of quality and depth at the 200-level or higher in the Materials Science and Engineering course offering. Courses must be taken for a letter grade. The proposed list of courses must be approved by department's advanced degree committee. Individual programs must be submitted to the student services manager at least one quarter prior to the quarter of the degree conferral. None of the units taken for the Ph.D. minor may overlap with any M.S. degree units.

Graduate Advising Expectations

The Department of Materials Science and Engineering is committed to providing academic advising in support of graduate student scholarly and professional development. When most effective, this advising relationship entails collaborative and sustained engagement by both the adviser and the advisee. As a best practice, advising expectations should be periodically discussed and reviewed to ensure mutual understanding. Both the adviser and the advisee are expected to maintain professionalism and integrity.

Faculty advisers guide students in key areas such as selecting courses, designing and conducting research, developing of teaching pedagogy, navigating policies and degree requirements, and exploring academic opportunities and professional pathways.

Graduate students are active contributors to the advising relationship, proactively seeking academic and professional guidance and taking responsibility for informing themselves of policies and degree requirements for their graduate program.

For a statement of University policy on graduate advising, see the "Graduate Advising (http://exploredegrees.stanford.edu/graduatedegrees/#advisingandcredentialstext)" section of this bulletin.

M.S. Advising

The Department of Materials Science and Engineering (MSE) is committed to providing academic advising in support of its M.S.

students' education and professional development. When most effective, this advising relationship entails collaborative engagement by both the adviser and the advisee. As a best practice, advising expectations should be discussed and reviewed to ensure mutual understanding. Both the adviser and the advisee are expected to maintain professionalism and integrity.

At the start of graduate study, each student is assigned a master's program adviser, a member of department faculty who provides guidance in course selection and in exploring academic opportunities and professional pathways. Usually, the same faculty member serves as program adviser for the duration of master's study, but the handbook does describe a process for formal adviser changes.

The MSE Graduate Handbook (https://mse.stanford.edu/student-resources) provides information and suggested timelines for advising meetings; however, ideally, the program adviser and student meet at least three times during the student's two-year degree. The first meeting between program adviser and student should occur once in Autumn Quarter of the first year to discuss the student's goals and objectives. Student and program adviser meet again in Spring Quarter to discuss the student's course plans and goals for the next academic year. The last meeting should be at the start of the quarter before the student's final quarter of study, and the program adviser and student review the student's coursework taken and the final quarter of study courses the student intends to take. It is expected that the student initiates these meetings.

In addition, the faculty Director of Graduate Studies (DGS) meets all the master's students during the MSE Orientation at the start of the first year and is available during the academic year by email and during office hours.The DGS or program adviser may initiate a meeting with any student they feel could be in academic distress.

The MSE student services team is also an important part of the master's advising team. They inform students and advisers about University and department requirements, procedures, and opportunities, and maintain the official records of advising assignments and approvals.

Finally, the department believes that graduate students are active contributors to the advising relationship, proactively seeking academic and professional guidance and taking responsibility for informing themselves of policies and degree requirements for their graduate program. As such, it expects students to read the monthly MSE Updates newsletter, which provides deadlines, web links, and other valuable information on graduate degree progress.

Ph.D. Advising

The Department of Materials Science and Engineering (MSE) is committed to providing academic advising in support of its Ph.D. students' education and professional development. When most effective, this advising relationship entails collaborative engagement by both the adviser and the advisee. As a best practice, advising expectations should be discussed and reviewed to ensure mutual understanding. Both the adviser and the advisee are expected to maintain professionalism and integrity.

Faculty advisers guide students in key areas such as selecting courses, designing and conducting research, developing teaching pedagogy, navigating policies and degree requirements, and exploring academic opportunities and professional pathways. The MSE Graduate Handbook (https://mse.stanford.edu/student-resources) provides information and suggested timelines for advising meetings in the different stages of the doctoral program, and this timeline is reviewed in the MSE Orientation held at the start of a student's doctoral program and at the annual MSE Graduate Updates meeting.

Ph.D. students are initially assigned a doctoral program adviser based on the interests expressed in their application. This faculty member provides initial guidance in course selection, assists students in exploring academic opportunities and professional pathways, and aids in identifying doctoral research opportunities. MSE does not require formal lab rotations, but students are strongly encouraged to explore research activities in two or three labs during their first academic year.

Students identify their doctoral research adviser prior to the end of February of their first year of study. The research supervisor assumes primary responsibility for the future direction of the student, taking on the roles previously filled by the program adviser, and ultimately directs the student's dissertation. Most students find an adviser from among the primary faculty members of the department. However, the research adviser may be a faculty member from another Stanford department who is familiar with supervising doctoral students and able to provide both research advising and funding for the duration of the doctoral program. When the research adviser is from outside the department, the student must also identify a department co-adviser from the department's primary faculty to provide guidance on departmental requirements, core coursework, and opportunities.

The faculty Director of Graduate Studies (DGS) meets with all the doctoral students during the MSE Orientation at the start of the first year and is available during the academic year by email and during office hours. The DGS or research adviser/co-adviser may initiate a meeting with any student they feel could be in academic or research distress.

The MSE student services team is also an important part of the doctoral advising team: they inform students and advisers about University and department requirements, procedures, and opportunities, and they maintain the official records of advising assignments and approvals. Students are encouraged to talk with the DGS and the student services office as they consider adviser selection, or for guidance in working with their adviser(s). Student services can discuss how a student can change program/research adviser(s), declare their Dissertation Reading Committee/Oral Exam Committee, and process for filing important paperwork.

The department's doctoral students are active contributors to the advising relationship, proactively seeking academic and professional guidance and taking responsibility for informing themselves of policies and degree requirements for their graduate program. As such the department expects students to read the monthly MSE Updates newsletter which provides deadlines, web links, and other valuable information on graduate degree progress.

Chair: Paul C. McIntyre

Associate Chair: Shan Xiang Wang

Professors: Mark L. Brongersma, Bruce M. Clemens, Yi Cui, Reinhold H. Dauskardt, Persis S. Drell, Paul C. McIntyre, Friedrich B. Prinz, Evan J. Reed, Robert Sinclair, Shan X. Wang

Associate Professors: Jennifer A. Dionne, Sarah C. Heilshorn, Aaron M. Lindenberg, Nicholas A. Melosh, Alberto Salleo, Andrew Spakowitz

Assistant Professors: Eric Appel, William Chueh, Guosong Hong

Courtesy Professors: Zhenan Bao, Stacey F. Bent, Wei Cai, Matteo Cargnello, Christopher Chidsey, Ian R. Fisher, Curtis W. Frank, Sanjiv Sam Gambhir, Wendy Gu, Geoffrey C. Gurtner, James S. Harris, Michael T. Longaker, Arunava Majumdar, Yoshio Nishi, James D. Plummer, Eric Pop, Krishna Saraswat, Jonathan Stebbins, Peter Yang

Lecturers: Ryan Brock, Ann Marshall, Arturas Vailionis

Adjunct Professors: Khalil Amine, Geraud Jean-Michel Dubois, Turgut M. Gur, Michael A. Kelly, Bryce Meredig, Kristin Persson, Baylor Triplett, Robert M. White

Emeriti: (Professors) David M. Barnett, Clayton W. Bates Jr., John C. Bravman, Richard H. Bube, Theodore H. Geballe, Robert A. Huggins, William D. Nix*, John C. Shyne, William A. Tiller, Robert L. White, Robert S. Feigelson* *(Professor, Research)*

*Recalled to active duty

Cognate Courses

		Units
AA 252	Techniques of Failure Analysis	3
AA 256	Mechanics of Composites	3
APPPHYS 270	Magnetism and Long Range Order in Solids	3
APPPHYS 272	Solid State Physics	3
APPPHYS 273	Solid State Physics II	3
CHEMENG 310	Microhydrodynamics	3
CHEMENG 345	Fundamentals and Applications of Spectroscopy	3
CHEMENG 355	Advanced Biochemical Engineering	3
EE 212	Integrated Circuit Fabrication Processes	3
EE 216	Principles and Models of Semiconductor Devices	3
EE 222	Applied Quantum Mechanics I	3
EE 223	Applied Quantum Mechanics II	3
EE 228	Basic Physics for Solid State Electronics	3
EE 311	Advanced Integrated Circuits Technology	3
EE 312	Integrated Circuit Fabrication Laboratory	3-4
EE 316	Advanced VLSI Devices	3
EE 327	Properties of Semiconductor Materials	3
EE 328		3
EE 329	The Electronic Structure of Surfaces and Interfaces	3
ENGR 50	Introduction to Materials Science, Nanotechnology Emphasis	4
ENGR 50E	Introduction to Materials Science, Energy Emphasis	4
ENGR 50M	Introduction to Materials Science, Biomaterials Emphasis	4
ME 329	Mechanical Analysis in Design	3
ME 335A	Finite Element Analysis	3
ME 335B	Finite Element Analysis	3
ME 335C	Finite Element Analysis	3
ME 345	Fatigue Design and Analysis	3
ME 381	Orthopaedic Bioengineering	3
ME 455	Complex Fluids and Non-Newtonian Flows	3
ME 457	Fluid Flow in Microdevices	3
PHYSICS 230	Graduate Quantum Mechanics I	3
PHYSICS 231	Graduate Quantum Mechanics II	3