MATERIALS SCIENCE AND ENGINEERING UNDERGRADUATE MAJOR

COVID-19-Related Degree Requirement Changes

For information on how Materials Science and Engineering degree requirements have been affected by the pandemic, see the 'COVID-19 Policies tab (http://exploredegrees.stanford.edu/schoolofengineering/materialsscienceandengineering/#covid19policies)' in the 'Materials Science and Engineering' of this bulletin. For University-wide policy changes related to the pandemic, see the 'COVID-19 and Academic Continuity (http://exploredegrees.stanford.edu/covid-19-policy-changes/' section of this bulletin.

The department offers a B.S. as well as a minor in Materials Science and Engineering.

Bachelor of Science in 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

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 coterminous degree program which leads to an M.S. in Materials Science and Engineering. Coterminous 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.

Degree Requirements

<table>
<thead>
<tr>
<th>Mathematics</th>
<th>Units</th>
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<tbody>
<tr>
<td>20 units minimum</td>
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<tr>
<td>Select one of the following:</td>
<td>5</td>
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<tr>
<td>MATH 51</td>
<td>Linear Algebra, Multivariable Calculus, and Modern Applications</td>
</tr>
<tr>
<td>CME 100/ ENGR 154</td>
<td>Vector Calculus for Engineers</td>
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<tr>
<td>Select one of the following:</td>
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<tr>
<td>MATH 52</td>
<td>Integral Calculus of Several Variables</td>
</tr>
<tr>
<td>CME 104/ ENGR 155B</td>
<td>Linear Algebra and Partial Differential Equations for Engineers</td>
</tr>
<tr>
<td>Select one of the following:</td>
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<tr>
<td>MATH 53</td>
<td>Ordinary Differential Equations with Linear Algebra</td>
</tr>
<tr>
<td>CME 102/ ENGR 155A</td>
<td>Ordinary Differential Equations for Engineers</td>
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<tr>
<td>One additional course</td>
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<table>
<thead>
<tr>
<th>Science</th>
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<td>20 units minimum</td>
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<tr>
<td>Must include a full year (15 units) of calculus-based physics or chemistry, with one quarter of study (5 units) in the other subject.</td>
<td>20</td>
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<table>
<thead>
<tr>
<th>Technology in Society</th>
<th>3-5</th>
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</thead>
<tbody>
<tr>
<td>One course minimum</td>
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<table>
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<tr>
<th>Engineering Fundamentals</th>
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<tr>
<td>Two courses minimum</td>
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<tr>
<td>Select one of the following:</td>
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<tr>
<td>ENGR 50</td>
<td>Introduction to Materials Science, Nanotechnology Emphasis</td>
</tr>
<tr>
<td>ENGR 50E</td>
<td>Introduction to Materials Science, Energy Emphasis</td>
</tr>
</tbody>
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ENGR 50M  Introduction to Materials Science, Biomaterials Emphasis  

At least one additional course 4

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 160  Nanomaterials Laboratory
MATSCI 161  Energy Materials Laboratory (WIM)
MATSCI 162  X-Ray Diffraction Laboratory
MATSCI 163  Mechanical Behavior Laboratory
MATSCI 164  Electronic and Photonic Materials and Devices Laboratory (WIM)
MATSCI 165  Nanoscale Materials Physics Computation Laboratory
MATSCI 166  Data Science and Machine Learning Approaches in Chemical and Materials Engineering

Focus Area Options 4, 6 13

Total Units 103-107

See a list of approved Engineering Fundamentals Courses at ughb.stanford.edu. Course chosen must be on the approved list the year taken.

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.

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/).

A course may only be counted towards one requirement; it may not be double-counted. For the 2020-2021 academic year, all courses taken for the major may be taken for either a letter grade (if offered by the instructor) or for CR and count towards degree requirements. 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 225  Biochips and Medical Imaging
MATSCI 380  Nano-Biotechnology
MATSCI 381  Biomaterials in Regenerative Medicine
MATSCI 384  Materials Advances for Neurotechnology: Materials Meet the Mind

Chemical Engineering
CHEM 171  Foundations of Physical Chemistry
CHEMENG 130  Micro and Nanoscale Fabrication Engineering
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  Foundations of Physical Chemistry
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 Photonic
EE 142  Engineering Electromagnetics (Formerly EE 141)
EE 155  Green Electronics
ME 210  Introduction to Mechatronics
MATS 343  Organic Semiconductors for Electronics and Photonics
MATS 346  Nanophotonics

**Energy Technology**

EE 293B  Fundamentals of Energy Processes
EE 155  Green Electronics
CEE 107A  Understanding Energy
EE 293B  Fundamentals of Energy Processes
MATS 156  Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution
MATS 302  Solar Cells
MATS 303  Principles, Materials and Devices of Batteries
ME 262  Physics of Wind Energy

**Materials Characterization Techniques**

MATS 320  Characterization of Materials
MATS 321  Transmission Electron Microscopy
MATS 322  Transmission Electron Microscopy Laboratory
MATS 323  Thin Film and Interface Microanalysis
MATS 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
MATS 198  Mechanical Properties of Materials
MATS 241  Mechanical Behavior of Nanomaterials
MATS 358  Fracture and Fatigue of Materials and Thin Film Structures
ME 80 or CEE 101A  Mechanics of Materials
ME 203  Design and Manufacturing

**Nanoscience**

ENGR 240  Introduction to Micro and Nano Electromechanical Systems
MATS 241  Mechanical Behavior of Nanomaterials
MATS 316  Nanoscale Science, Engineering, and Technology
MATS 320  Nanophotonics
MATS 346  Nanophotonics
MATS 347  Magnetic materials in nanotechnology, sensing, and energy
MATS 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

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 Undergraduate Research and participation in an independent research project over three sequential full quarters
3. Completion of a faculty-approved thesis
4. Participation in either a poster or oral presentation of thesis work at a Stanford Symposium/event or, at your faculty advisor's discretion, in a comparable public event.

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 faculty research advisor and agree on a proposed research topic. If the research advisor is not a member of the MSE faculty or not a member of the School of Engineering Academic Council, students must have a second advisor who fulfills these requirements.
- Compose a brief (less than 1 page) summary of proposed research, including a proposed title, and submit along with unofficial transcript (prior to application).
- Submit application to MATSCI student services (Durand 113) 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 (students may petition out of unit requirement with faculty advisor approval). All quarters must focus on the same topic. Maintain the same faculty adviser throughout, if possible.
- Present either a poster or oral presentation of thesis work at a Stanford event or, at the faculty advisor's discretion, in a comparable public event.
- Submit final drafts of an honors thesis to two faculty readers (one must be your research advisor, and one must be an MSE faculty member/SoE Academic Council member) at least one quarter prior to graduation. Both must approve the thesis by completing the signature page (https://mse.stanford.edu/student-resources/forms/undergraduate/).
- Submit to MATSCI student services (Durand 113) one copy of the honors thesis and signed signature page (in electronic or physical form) at least one quarter prior to graduation.

**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:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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<td><strong>Materials Science Fundamentals and Engineering Depth</strong></td>
<td>24</td>
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<tr>
<td>Select six of the following:</td>
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<tr>
<td>MATSCI 142</td>
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<td>Organic and Biological Materials</td>
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<td>MATSCI 192</td>
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<td>MATSCI 199</td>
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<td>Electronic and Optical Properties of Solids</td>
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Total Units: 28