MATERIALS SCIENCE AND ENGINEERING UNDERGRADUATE MAJOR

See the "Department of Materials Science and Engineering (http://exploredegrees.stanford.edu/schoolofengineering/materialscienceandengineering)" section of this bulletin for additional information on the department, and its programs and faculty.

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.

Requirements

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Units</th>
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<tbody>
<tr>
<td>Mathematics</td>
<td></td>
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<tr>
<td>20 units minimum</td>
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<tr>
<td>Select one of the following:</td>
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<tr>
<td>MATH 51                              Linear Algebra, Multivariable Calculus, and Modern Applications</td>
<td>5</td>
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<tr>
<td>CME 100/ ENGR 154                      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                              Integral Calculus of Several Variables</td>
<td>5</td>
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<tr>
<td>CME 104/ ENGR 155B                Linear Algebra and Partial Differential Equations for Engineers</td>
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<tr>
<td>Select one of the following:</td>
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<tr>
<td>MATH 53                   Ordinary Differential Equations with Linear Algebra</td>
<td>5</td>
</tr>
<tr>
<td>CME 102/ ENGR 155A                Ordinary Differential Equations for Engineers</td>
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<tr>
<td>One additional course 1</td>
<td>5</td>
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<tr>
<td>Science</td>
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<tr>
<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>
</tr>
<tr>
<td>Technology in Society</td>
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<tr>
<td>One course minimum</td>
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<tr>
<td>Engineering Fundamentals</td>
<td>3-5</td>
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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                      Introduction to Materials Science, Nanotechnology Emphasis</td>
<td>4</td>
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<tr>
<td>ENGR 50E                     Introduction to Materials Science, Energy Emphasis</td>
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</tr>
<tr>
<td>ENGR 50M                  Introduction to Materials Science, Biomaterials Emphasis</td>
<td>4</td>
</tr>
<tr>
<td>At least one additional course 4</td>
<td>3-5</td>
</tr>
</tbody>
</table>

Department Requirements: MSE Fundamentals, Depth & Focus Areas

Materials Science Fundamentals: All of the following courses: 16

<table>
<thead>
<tr>
<th>Materials Science Fundamentals</th>
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</thead>
<tbody>
<tr>
<td>MATSCI 142 Quantum Mechanics of Nanoscale Materials</td>
<td></td>
</tr>
<tr>
<td>MATSCI 143 Materials Structure and Characterization</td>
<td></td>
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<tr>
<td>MATSCI 144 Thermodynamic Evaluation of Green Energy Technologies</td>
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<tr>
<td>MATSCI 145 Kinetics of Materials Synthesis</td>
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</tbody>
</table>
Focus Area Options

Two of the following courses:

- 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**

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 225 Biosips 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 Physical Chemistry I
- CHEMENG 130
- 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 141I)
- 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
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 107A</td>
<td>Understanding Energy</td>
</tr>
<tr>
<td>EE 293B</td>
<td>Fundamentals of Energy Processes</td>
</tr>
<tr>
<td>MATSCI 156</td>
<td>Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution</td>
</tr>
<tr>
<td>MATSCI 302</td>
<td>Solar Cells</td>
</tr>
<tr>
<td>MATSCI 303</td>
<td>Principles, Materials and Devices of Batteries</td>
</tr>
<tr>
<td>ME 262</td>
<td>Physics of Wind Energy</td>
</tr>
</tbody>
</table>

### 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 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.

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

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### 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 adviser and graduate student mentors. The main requirements are as follows:

1. Application to the honors program (must be pre-approved by faculty adviser)
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 adviser’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 adviser and agree on a proposed research topic. If the research adviser is not a member of the MSE faculty, or not a member of the School of Engineering Academic Council, students must have a second adviser 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 and signed application/faculty endorsement (https://mse.stanford.edu/student-resources/forms/undergraduate).
- 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 for a letter grade (students may petition out of unit requirement with faculty adviser 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 adviser’s discretion, in a comparable public event.
- Submit final drafts of an honors thesis to two faculty readers (one must be your research adviser, 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.

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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>Title</th>
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<tbody>
<tr>
<td><strong>Engineering Fundamentals</strong></td>
<td></td>
</tr>
<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>
<tr>
<td>ENGR 50M</td>
<td>Introduction to Materials Science, Biomaterials Emphasis</td>
</tr>
<tr>
<td><strong>Materials Science Fundamentals and Engineering Depth</strong></td>
<td><strong>Total Units 24</strong></td>
</tr>
<tr>
<td>MATSCI 142</td>
<td>Quantum Mechanics of Nanoscale Materials</td>
</tr>
<tr>
<td>MATSCI 143</td>
<td>Materials Structure and Characterization</td>
</tr>
<tr>
<td>MATSCI 144</td>
<td>Thermodynamic Evaluation of Green Energy Technologies</td>
</tr>
<tr>
<td>MATSCI 145</td>
<td>Kinetics of Materials Synthesis</td>
</tr>
<tr>
<td>MATSCI 151</td>
<td>Microstructure and Mechanical Properties</td>
</tr>
<tr>
<td>MATSCI 152</td>
<td>Electronic Materials Engineering</td>
</tr>
<tr>
<td>MATSCI 156</td>
<td>Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution</td>
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<td>MATSCI 158</td>
<td>Soft Matter in Biomedical Devices, Microelectronics, and Everyday Life</td>
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<tr>
<td>MATSCI 160</td>
<td>Nanomaterials Laboratory</td>
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<tr>
<td>MATSCI 161</td>
<td>Energy Materials Laboratory</td>
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<td>MATSCI 162</td>
<td>X-Ray Diffraction Laboratory</td>
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<tr>
<td>MATSCI 163</td>
<td>Mechanical Behavior Laboratory</td>
</tr>
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<td>MATSCI 164</td>
<td>Electronic and Photonic Materials and Devices Laboratory</td>
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<tr>
<td>MATSCI 165</td>
<td>Nanoscale Materials Physics Computation Laboratory</td>
</tr>
<tr>
<td>MATSCI 190</td>
<td>Organic and Biological Materials</td>
</tr>
<tr>
<td>MATSCI 192</td>
<td>Materials Chemistry</td>
</tr>
<tr>
<td>MATSCI 193</td>
<td>Atomic Arrangements in Solids</td>
</tr>
<tr>
<td>MATSCI 194</td>
<td>Thermodynamics and Phase Equilibria</td>
</tr>
<tr>
<td>MATSCI 195</td>
<td>Waves and Diffraction in Solids</td>
</tr>
<tr>
<td>MATSCI 196</td>
<td>Defects in Crystalline Solids</td>
</tr>
<tr>
<td>MATSCI 197</td>
<td>Rate Processes in Materials</td>
</tr>
<tr>
<td>MATSCI 198</td>
<td>Mechanical Properties of Materials</td>
</tr>
<tr>
<td>MATSCI 199</td>
<td>Electronic and Optical Properties of Solids</td>
</tr>
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**Total Units 28**