Department of Materials Science and Engineering

Elizabeth Dickey, Head
Location: Wean Hall 3327
materials.cmu.edu (http://materials.cmu.edu)

Materials Science & Engineering (MSE) is an engineering discipline that applies the tools of basic and applied sciences and engineering to the manufacture and application of materials and devices. The four broad classes of Materials to which this paradigm is applied are metals, polymers, ceramics, and composites. Essentially every technology (historical, modern, and future) depends on materials development and innovation.

The overarching paradigm of MSE is to determine and to exploit the connection between processing, structure, and properties of materials to engineer materials that fit the performance criteria for specific applications, which are useful for the technological needs of our society. In addition to this product specific knowledge, MSE is concerned with the implications of materials production and their sustainable use on the environment and energy resources.

Graduates of the MSE department are pursuing careers in an expanding spectrum of companies, national laboratories, and universities. Their activities cover a wide range of materials related endeavors that include microelectronics, energy production and storage, biomedical applications, aerospace, information technology, nanotechnology, manufacturing and materials production. Many of our undergraduate alumni choose to attend graduate school; they are accepted into the top Materials graduate schools in the country.

The standard curriculum of the department provides fundamental training for all materials science and engineering areas (see www.cmu.edu/engineering/materials/undergraduate_program/curriculum (http://www.cmu.edu/engineering/materials/undergraduate_program/curriculum/)). The core courses provide understanding and training on tools for working with the (atomic) structure of materials that governs their properties, the thermodynamic relationships that govern the stability of materials, and the rates at which changes take place in materials. Students complete their learning with a capstone design experience in the final year, which integrates their materials knowledge and training with engineering team skill development. To supplement the core course program, students may also participate in the current research programs of the faculty and conduct undergraduate research projects as part of their program of study.

While the core program is focused on the understanding of the internal or surface structure of materials in order to predict and engineer their properties, it is a flexible program that allows students to focus within a chosen material class, whether it is ceramics, semiconductors, metals, composites, magnetic or optical materials, bio-materials or polymers. The program also permits the option of cross concentration in the one or more of the areas of application such as electronic materials*, engineering design*, biomedical engineering*, environmental engineering*, manufacturing engineering*, mechanical behavior of materials*, biomedical and health engineering**, and engineering and public policy**, is also available. (* = Designated Minor, ** = Double Major). Our curriculum is designed to provide a strong foundation in fundamental knowledge and skills that provide an excellent base for our graduates planning to continue on to graduate studies. For our graduates who seek employment in industry, the program provides the foundation on which a graduate can build his/her domain specific knowledge. For students that develop or seek opportunities in other disciplines after graduation, the MSE curriculum provides a modern liberal education combined with the engineering rigor, i.e. one that inculcates upon a thoughtful, problem-solving approach to professional life. It is thus the goal of our education to provide a global and modern education in Materials Science and Engineering to support our graduates during their careers in materials industries or as a foundation for further studies in any of the leading global institutions of graduate education.

Accreditation
The MSE Undergraduate Program is accredited by the Engineering Accreditation Commission of ABET, www.abet.org.

Educational Objectives
The faculty of the Department of Materials Science and Engineering, in consultation with students, alumni and other interested parties, has decided that the overarching objective of the MSE curriculum is to provide an education that enables our graduates to be productive and fulfilled professionals throughout their careers.

Graduates with a B.S. degree from the Materials Science and Engineering Program will attain within a few years after graduation

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, economic, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Curriculum
Minimum units required for B.S. in Materials Science & Engineering

381

Standard Program

Freshman Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-120</td>
<td>Differential and Integral Calculus</td>
</tr>
<tr>
<td>27-100</td>
<td>Engineering the Materials of the Future*</td>
</tr>
<tr>
<td>99-101</td>
<td>Computing @ Carnegie Mellon</td>
</tr>
<tr>
<td>xx-xxx</td>
<td>General Education Course</td>
</tr>
<tr>
<td>33-141</td>
<td>Physics I for Engineering Students</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Spring</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-122</td>
<td>Integration and Approximation</td>
</tr>
<tr>
<td>xx-xxx</td>
<td>Second Introductory Engineering Course</td>
</tr>
<tr>
<td>33-142</td>
<td>Physics II for Engineering and Physics Students</td>
</tr>
</tbody>
</table>
### Sophomore Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Units</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>27-201</td>
<td>Structure of Materials</td>
<td>27-202</td>
</tr>
<tr>
<td>27-210</td>
<td>Materials Engineering Essentials</td>
<td>27-216</td>
</tr>
<tr>
<td>27-215</td>
<td>Thermodynamics of Materials</td>
<td>27-217</td>
</tr>
<tr>
<td>09-105</td>
<td>Introduction to Modern Chemistry **</td>
<td>21-254</td>
</tr>
<tr>
<td>or 15-112</td>
<td>Fundamentals of Programming and Computer Science</td>
<td>xx-xxx</td>
</tr>
<tr>
<td>39-210</td>
<td>Experiential Learning I</td>
<td>xx-xxx</td>
</tr>
<tr>
<td>27-709</td>
<td>Engineering Biomatериалs</td>
<td>27-717</td>
</tr>
</tbody>
</table>

** These courses must be taken before the end of the sophomore year, but need not be taken in the same order or semester as listed above.

### Junior Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Units</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>27-301</td>
<td>Microstructure and Properties I</td>
<td>27-367</td>
</tr>
<tr>
<td>xx-xxx</td>
<td>Free Elective [1]</td>
<td>xx-xxx</td>
</tr>
<tr>
<td>or 09-217</td>
<td>Organic Chemistry I</td>
<td>27-xxx</td>
</tr>
<tr>
<td>or 03-121</td>
<td>Modern Biology</td>
<td>xx-xxx</td>
</tr>
<tr>
<td>xx-xxx</td>
<td>General Education Course</td>
<td>36-220</td>
</tr>
<tr>
<td>39-310</td>
<td>Experiential Learning III</td>
<td>42-610</td>
</tr>
</tbody>
</table>

### Senior Year

<table>
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<tr>
<th>Fall</th>
<th>Units</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>27-401</td>
<td>MSE Capstone Course I</td>
<td>27-402</td>
</tr>
<tr>
<td>xx-xxx</td>
<td>General Education Course</td>
<td>xx-xxx</td>
</tr>
<tr>
<td>xx-xxx</td>
<td>General Education Course</td>
<td>xx-xxx</td>
</tr>
</tbody>
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### Notes on the Curriculum

#### Academic Advising
Paige Houser is the academic advisor for all MSE students.

#### Quality Point Average
In addition to the College requirement of a minimum cumulative quality point average of 2.00 for all courses taken beyond the freshman year, the Department requires a quality point average of 2.00 or higher in courses taken in the MSE department. Students may repeat a course to achieve the QPA requirement. Only the higher grade will be used for this departmental calculation.

#### Biomedical Engineering Additional Major
Students pursuing the additional major in Biomedical Engineering are required to take the following as an elective.

27-709 | Engineering Biomatериалs | 12

** All mathematics (21-xxx) courses required for the engineering degree taken at Carnegie Mellon must have a minimum grade of C in order to be counted toward the graduation requirement for the BS engineering degree.

#### Integrated B.S./M.S. Program
Undergraduates who excel academically have the unique opportunity to receive simultaneously or sequentially both B.S. and M.S. degrees from the department. The primary purpose of the integrated Master and Bachelor (IMB) Degree Program is to provide students with superior breadth and depth in technical material, which will better prepare them for careers in industry. Students interested in pursuing the IMB Degrees are encouraged to begin taking some of the required graduate courses before their last year. The MSE department offers two M.S. degrees: one in Materials Science and Engineering (MSE), a coursework degree, and one in Materials Science (MS), a coursework + research degree. The IMB Degree Program to obtain an M.S. in MSE (MS) degree normally requires two (three to four) additional

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* The Materials in Engineering course 27-100 may also be taken in the spring semester, and must be taken before the end of the sophomore year (the H&SS Elective in the Sophomore Spring may be moved to later in the program to accommodate the 27-100 course).
full academic semesters of coursework (coursework + research) beyond the B.S. Degree Requirements (normally eight academic semesters). Experience has shown that students complete the IMB program in eight to ten full academic semesters after enrolling at CMU.

Degree Requirements
IMB students can be enrolled in either the M.S. in MSE (coursework) or the M.S. in MS (coursework + research) degree programs, depending on their preference. Students must meet the requirements of either the M.S. in MSE or the M.S. in MS degree programs, as well as any specially stated rules below.

Eligibility
The IMB Program is available to all undergraduates who maintain a cumulative GPA of 3.0 or better, including the freshman year and the years in which they are enrolled in the IMB. Exceptions can be made by the Department on the basis of other factors, including extenuating (e.g., medical) circumstances, improvement in grades, strong recommendation letters, etc. Students become eligible to apply to the program during the spring semester of their junior year (5th semester), or the semester in which they accumulate 280 or more units, whichever is earlier.

Enrollment
Students interested in the IMB program are not required to follow the formal application process for acceptance into the MSE graduate program. There is no requirement to provide a formal application, application fee, GRE scores, recommendation letters, official transcripts, or a statement of purpose. Interested students are encouraged to request acceptance into the program by contacting the Department Head of MSE by email prior to the middle of the semester in which they become eligible.

Requirements to Enroll as a Graduate Student
If a student takes more than 8 semesters to complete both the B.S. and M.S. in MSE (coursework), then he or she must be a graduate student for at least one full-time 15-week academic semester (Fall or Spring) before graduating, or not they have already completed their B.S. degree.

If a student takes more than 8 semesters to complete both the B.S. and M.S. in MS (coursework + research), then he or she must be a graduate student for at least two full-time 15-week academic semesters (Fall or Spring) before graduating, or not they have already completed their B.S. degree.

Tuition Assistance
When a student is a full-time graduate student through the IMB program, the department is able to provide some tuition assistance through optional Teaching Assistantships.

Additional Information
Once the student has been accepted, the student should meet with his or her IMB academic advisor(s) to determine a course schedule.

The student must indicate to the departmental program coordinator at which point they intend, if necessary, to register as a graduate student.

Once a student in the IMB program has completed all of the requirements for the B.S. degree, he or she should become a graduate student.

To determine the most appropriate time for an undergraduate student to become a graduate student, he or she should consult with Enrollment Services to understand how becoming a graduate student will affect financial aid.

Faculty
CHRISTOPHER BETTINGER, Professor – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2010-
Micheal BOCKSTALLER, Professor – Ph.D., Max-Planck Institute for Polymer Research; Carnegie Mellon, 2005-
ITZHAO COHEN-KARNI, Associate Professor – Ph.D., Harvard University; Carnegie Mellon, 2013-
ELIZABETH C. DICKEY, Professor and Department Head – Ph.D., Northwestern University; Carnegie Mellon, 2021-
MARCE DE GRAEF, Professor – Ph.D., Catholic University Leuven (Belgium); Carnegie Mellon, 1993-
ADAM FEINBERG, Professor – Ph.D., University of Florida; Carnegie Mellon, 2010-
ROBERT HEARD, Teaching Professor – Ph.D., University of Toronto; Carnegie Mellon, 2003-
ELIZABETH A. HOLM, Professor – Ph.D., University of Michigan; Carnegie Mellon, 2012-
MOHAMMAD F. ISLAM, Professor of Materials Science and Engineering – Ph.D., Lehigh University; Carnegie Mellon, 2005-
AMANDA R. KRAUSE, Assistant Professor – Ph.D., Brown University; Carnegie Mellon, 2022-
RACHEL KURCHIN, Assistant Research Professor – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2022-
NOA MAROM, Associate Professor – Ph.D., Weizmann Institute of Science; Carnegie Mellon, 2016-
MICHAEL E. MCHENRY, Professor – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1989-
THOMAS O’CONNOR, Assistant Professor – Ph.D., Johns Hopkins University; Carnegie Mellon, 2021-
P. CHRIS PISTORIUS, Professor and Associate Department Head – Ph.D., University of Cambridge; Carnegie Mellon, 2008-
LISA M. PORTER, Professor – Ph.D., North Carolina State; Carnegie Mellon, 1997-
GREGORY S. ROHRER, Professor – Ph.D., University of Pennsylvania; Carnegie Mellon, 1990-
ANTHONY D. ROLLETT, Professor – Ph.D., Drexel University; Carnegie Mellon, 1995-
PAUL A. SALVADOR, Professor and Executive Director of the Masters program in Energy Science, Technology and Policy – Ph.D., Northwestern University; Carnegie Mellon, 1999-
MAREK SKOWRONSKI, Professor – Ph.D., Warsaw University; Carnegie Mellon, 1988-
VINCENT SOKALSKI, Teaching Professor – Ph.D., Carnegie Mellon; Carnegie Mellon, 2013-
S. MOHAMED EH TAHERI-MOUSAVI, Assistant Professor – Ph.D., Ecole Polytechnique Federale de Lausanne; Carnegie Mellon, 2022-
ELIAS TOWE, Professor – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2001-
BRYAN A. WEBLER, Professor – Ph.D., Carnegie Mellon; Carnegie Mellon, 2013-
JAY WHITACRE, Professor and Director of the Wilton E. Scott Institute for Energy Innovation – Ph.D., University of Michigan; Carnegie Mellon, 2007-

Affiliated Faculty
ROSALYN ABBOT, Assistant Professor of Biomedical Engineering – Ph.D., University of Vermont;
AMIT ACHARYA, Professor, Civil and Environmental Engineering – Ph.D., University of Illinois, Urbana-Champaign; Carnegie Mellon, 2000-
JAMES BAIN, Professor, Electrical and Computer Engineering – Ph.D., Stanford University; Carnegie Mellon, 1993-
JACK BEUTH, Professor, Mechanical Engineering – Ph.D., Harvard University; Carnegie Mellon, 1992-
PHIL CAMPBELL, Research Professor, Institute for Complex Engineered Systems - Ph.D., The Pennsylvania State University; Carnegie Mellon, 2000-
Kris NoEL DAHL, Professor of Chemical Engineering and BioMedical Engineering and Materials Science and Engineering – Ph.D., University of Pennsylvania; Carnegie Mellon, 2006-
KAUSHIK DAYAL, Professor of Civil and Environmental Engineering – Ph.D., California Institute of Technology; Carnegie Mellon, 2008-
MAARTEN DE BOER, Professor of Mechanical Engineering – Ph.D., University of Minnesota; Carnegie Mellon, 2007-
AMIR BARATI FARIMANI, Assistant Professor – Ph.D., University of Illinois at Urbana-Champaign; Carnegie Mellon, 2018-
RANDALL FEENSTRA, Professor, Physics – Ph.D., California Institute of Technology; Carnegie Mellon, 1995-
ERICA FUCHS, Professor – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2007-
STEPHEN GAROFF, Professor Emeritus, Physics – Ph.D., Harvard University; Carnegie Mellon, 1988-

ANDREW GELLMAN, Lord Professor, Chemical Engineering – Ph.D., University of California, Berkeley; Carnegie Mellon, 1992-

REEJA JAYAN, Associate Professor, Mechanical Engineering – Ph.D., University of Texas at Austin; Carnegie Mellon, 2015-

DAVID KINDERLEHRER, Professor, Mathematical Sciences – Ph.D., University of California, Berkeley; Carnegie Mellon, 1990-

JOHN KITCHIN, Professor of Chemical Engineering – Ph.D., University of Delaware; Carnegie Mellon, 2006-

TOMEK KOWALWESKI, Professor of Chemistry – Ph.D., Polish Academy of Sciences; Carnegie Mellon, 2000-

SHAWN LITSTER, Professor, Mechanical Engineering – Ph.D., Stanford University; Carnegie Mellon, 2008-

SARA MAJETICH, Professor, Physics – Ph.D., University of Georgia; Carnegie Mellon, 1990-

CARMEL MAJIDI, Professor of Mechanical Engineering – Ph.D., University of California; Carnegie Mellon, 2011-

JONATHAN MALEN, Professor – Ph.D., University of California, Berkeley; Carnegie Mellon, 2009-

KRZYSZTOF MATYJASZEWSKI, J.C. Warner Professor of Natural Sciences, Department of Chemistry and Materials Science and Engineering – Ph.D., Polytechnical University of Łódź, Poland; Carnegie Mellon, 1985-

ALAN MCGAUGHEY, Professor of Mechanical Engineering – Ph.D., University of Michigan; Carnegie Mellon, 2005-

SNEHA PRABHA NARRA, Assistant Professor, Mechanical Engineering – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2021-

O. BURAK OZDOGANLAR, Professor of Mechanical Engineering – Ph.D., University of Michigan; Carnegie Mellon, 2004-

RAHUL PANAT, Associate Professor of Mechanical Engineering – Ph.D., University of Illinois at Urbana-Champaign; Carnegie Mellon, 2017-

ROBERT Sekerka, University Professor Emeritus, Physics, Mathematics and Materials Science – Ph.D., Harvard; Carnegie Mellon, 1969-

ROBERT SUTER, Professor Emeritus – Ph.D., Clark University; Carnegie Mellon University; Carnegie Mellon, 1976, 1981-

ZACHARY ULISSI, Associate Professor, Chemical Engineering – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon University; Carnegie Mellon, 2016-

VENKAT VISWANATHAN, Associate Professor, Mechanical Engineering – Ph.D., Stanford University; Carnegie Mellon, 2013-

LYNN WALKER, Professor of Chemical Engineering – Ph.D., University of Delaware; Carnegie Mellon, 1997-

NEWELL R. WASHBURN, Associate Professor of Chemistry, Biomedical Engineering and Materials Science and Engineering – Ph.D., University of California, Berkeley; Carnegie Mellon, 2004-

MICHAEL WIDOM, Professor of Physics – Ph.D., University of Chicago; Carnegie Mellon, 1985-

LINING YAO, Assistant Professor of Human-Computer Interaction Institute and College of Engineering – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2017-

JIAN-GANG ZHU, Professor, Electrical and Computer Engineering – Ph.D., University of California at San Diego., Carnegie Mellon, 1997-

Emeriti Faculty

ROBERT F. DAVIS, Professor Emeritus – Ph.D., University of California, Berkeley; Carnegie Mellon, 2004-

WARREN M. GARRISON, Professor Emeritus of Materials Science and Engineering – Ph.D., University of California at Berkeley; Carnegie Mellon, 1984-

DAVID E. LAUGHLIN, Professor Emeritus – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 1974-

THADDEUS B. MASSALSKI, Professor Emeritus of Physics, Materials Science and Engineering – Ph.D., D.Sc., University of Birmingham, England D.Sc. (h), University of Warsaw, Poland.; Carnegie Mellon, 1959-