Department of Materials Science and Engineering

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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*, environmental engineering*, additive manufacturing*, mechanical behavior of materials*, biomedical engineering**, and engineering and public policy**, is also available. (*= Designated Minor, **= Additional 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 rigors, 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 Materials Science and Engineering Program is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org, under the commission's General Criteria and the Program Criteria for Materials(1), Metallurgical(2), Ceramics(3) and Similarly Named Engineering Programs.

Program Educational Objectives

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

(1) attain success in a professional position and/or a top graduate school that builds upon their MSE background

(2) exhibit professionalism and leadership in contemporary, interdisciplinary engineering practice based on materials, while accounting for the impact of their profession on an evolving, global society

(3) contribute to innovative designs of technological systems using principles of materials science and engineering

(4) make effective contributions as an individual, team member, and/or a leader to effect global, economic, environmental, and/or societal impact

Student Outcomes

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, 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 requrired for B.S. in Materials Science & Engineering	381

Standard Program

Freshman Year

Fall		Units
21-120	Differential and Integral Calculus	10
27-100	Engineering the Materials of the Future *	12
99-101	Core@CMU	3
xx-xxx	General Education Course	9
33-141	Physics I for Engineering Students	12
		46

Spring		Units
21-122	Integration and Approximation	10
xx-xxx	Second Introductory Engineering Course	12
33-142	Physics II for Engineering and Physics Students	12
76-101	Interpretation and Argument	9
		43

Sophomore Year

Fall		Units
27-201	Structure of Materials	9
27-210	Materials Engineering Essentials	6
27-215	Thermodynamics of Materials	12
09-105	Introduction to Modern Chemistry I **	10

21-254	Linear Algebra and Vector Calculus for Engineers	11
15-110	Principles of Computing	10
or 15-112	Fundamentals of Programming and Computer Science	
39-210	Experiential Learning I	0
		58

Spring		Units
27-202	Defects in Materials	9
27-216	Transport in Materials	9
27-217	Phase Relations and Diagrams	12
21-260	Differential Equations	9
39-220	Experiential Learning II	0
xx-xxx	General Education Course	9
		48

Junior Year

Fall		Units
27-301	Microstructure and Properties I	9
27-xxx	MSE Restricted Elective [1]	9
xx-xxx	Free Elective [1]	9
33-225	Quantum Physics and Structure of Matter	9
	or	
or 09-217	Organic Chemistry I	
or 03-121	Modern Biology	
xx-xxx	General Education Course	9
39-310	Experiential Learning III	0
		45

Spring		Units
27-367	Selection and Performance of Materials	6
27-305	Introduction to Materials Characterization	6
xx-xxx	General Education Course	9
27-xxx	MSE Restricted Elective [2]	9
27-xxx	MSE Restricted Elective [3]	9
xx-xxx	Free Elective [2]	9
36-220	Engineering Statistics and Quality Control	9
		57

Senior Year

Fall		Units
27-401	MSE Capstone Course I	6
27-xxx	MSE Restricted Elective [4]	9
xx-xxx	Free Elective [3]	9
xx-xxx	General Education Course	9
xx-xxx	General Education Course	9
		42

Spring		Units
27-402	MSE Capstone Course II	6
27-xxx	MSE Approved Technical Elective	9
xx-xxx	Free Elective [4]	9
xx-xxx	Free Elective [5]	9
xx-xxx	General Education Course	9
		42

* 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).

** 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.

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.

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.

MSE Approved Technical Elective

Students are required to take at least 9 units of approved technical electives. Students may take a course from another CIT department to fulfill this requirement or choose an additional 9 units of MSE Restricted Electives. Courses on the exclusion list **cannot** be counted as a technical elective. Students who are pursuing an additional major or minor within CIT should check with their academic advisor regarding double counting of this course.

Courses on this list cannot be counted as a technical elective		Units
06-426	Experimental Colloid Surface Science	9
06-466	Experimental Polymer Science	9
12-201	Geology	9
18-202	Mathematical Foundations of Electrical Engineering	12
18-300	Fundamentals of Electromagnetics	12
24-311	Numerical Methods	12
42-202	Physiology	9
42-610	Introduction to Biomaterials	9

MSE Restricted Electives

Each student in the program must take at least 36 units of MSE restricted electives. Up to 18 units of MSE research can count toward the restricted electives.

All 27-3xx, 27-4xx, 27-5xx, 27-6xx (with the exception of) and 27-7xx level and cross listed courses will fulfill the MSE Restricted Elective Requirement along with the following non-MSE courses:

Non-MSE courses that count as restricted electives		Units
06-609	Physical Chemistry of Macromolecules	9
09-509	Physical Chemistry of Macromolecules	9
12-411	Project Management for Engineering and Construction	9
12-631	Structural Design	12
18-310	Fundamentals of Semiconductor Devices	12
24-262	Mechanics II: 3D Design	10
24-341	Manufacturing Sciences	9
42-667	Biofabrication and Bioprinting	12

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 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 QPA 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 request acceptance into the program by contacting the MSE academic advisor 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 14-week academic semester (Fall or Spring) before graduating, whether or not they have already completed their B.S. degree.

Students should refer to the College of Engineering and University policies regarding enrollment status.

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.

Faculty

CHRISTOPHER BETTINGER, Professor – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2010–

MICHAEL BOCKSTALLER, Professor – Ph.D., Max-Planck Institute for Polymer Research; Carnegie Mellon, 2005–

ITZHAQ COHEN-KARNI, Professor – Ph.D., Harvard University; Carnegie Mellon, 2013–

ELIZABETH C. DICKEY, Professor and Department Head – Ph.D., Northwestern University; Carnegie Mellon, 2021–

MARC 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–

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. MOHADESEH 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 – Ph.D., University of Michigan; Carnegie Mellon, 2007–

Affiliated Faculty

ROSALYN ABBOT, Assistant Professor of Biomedical Engineering – Ph.D., Universtiy 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–

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; 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–

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 Engineeering – 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–

SHENG SHEN, Professor, Mechanical Engineering – Ph.D. , Massachusetts Institute of Technology; Carnegie Mellon, 2011–

ROBERT SUTER, Professor Emeritus – Ph.D. , Clark University; Carnegie Mellon University; Carnegie Mellon, 1978, 1981–

FATMA ZEYNEP TEMEL, Assistant Professor, Robotics Institute – Ph.D., Sabanci University; Carnegie Mellon, 2019–

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

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–

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

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

PAUL WYNBLATT, Professor Emeritus of Materials Science and Engineering – Ph.D., University of California at Berkeley; Carnegie Mellon, 1981–

Adjunct Faculty

AHARON INSPEKTOR, Adjunct Faculty, Materials Science and Engineering – Ph.D., Technion Israel Institute of Technology; Carnegie Mellon, 2019–