Engineering Mechanics, Ph.D.

The master of science and doctor of philosophy degrees in engineering mechanics are offered within a graduate program covering contemporary areas in both theoretical and applied mechanics. With the guidance of a major professor, a program can be designed to meet an individual student’s needs and interests.

The program is broadly structured into several main areas of instruction and research interests in mechanics of materials and astronautics: continuum mechanics, computational mechanics, dynamics and vibration, fluid mechanics, nanomechanics, solid mechanics, and biomechanics. Related fields in which minor work may be done include civil and environmental engineering, chemical and biological engineering, electrical and computer engineering, materials science, mechanical engineering, nuclear engineering and engineering physics, physics, geological engineering and geology, mathematics, statistics, and computer science.

Current faculty research interests include adhesive-bonded joints; composites; failure criteria; analytical and computational solid mechanics; analytical and computational dynamics; multibody dynamics; analytical and computational active and passive space-structure control systems; dynamic stability; nonlinear fracture mechanics of traditional and advanced materials; continuum mechanics; modal analysis; nanomechanics and nanotribology; fluid-structure interaction; non-Newtonian fluid flow; structural mechanics; viscoelasticity; viscoplasticity; cell mechanics; and biomechanics.

Laboratories are well equipped for experimental testing and research; these include holography, Moire, atomic force microscopy, vibration testing, and other optical methods for experimental mechanics research. The department has access to collegewide facilities. The Wisconsin Laboratory for Structures and Materials Testing has facilities for testing large structures, fatigue and vibration labs, and complements the department’s laboratories. The Materials Science Center provides state-of-the-art instrumentation, support facilities, and expert technical assistance for research and education in materials. Its facilities include scanning and transmission electron microscopes, image processing and analysis systems, surface and thin film characterization facilities, and x-ray diffraction facilities.

Admissions

Please consult the table below for key information about this degree program’s admissions requirements. The program may have more detailed admissions requirements, which can be found below the table or on the program’s website. Graduate admissions is a two-step process between academic programs and the Graduate School. Applicants must meet the minimum requirements (https://grad.wisc.edu/apply/requirements/) of the Graduate School as well as the program(s).

Once you have researched the graduate program(s) you are interested in, apply online (https://grad.wisc.edu/apply/).

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall Deadline</td>
<td>December 15</td>
</tr>
<tr>
<td>Spring Deadline</td>
<td>October 1</td>
</tr>
<tr>
<td>Summer Deadline</td>
<td>December 15</td>
</tr>
</tbody>
</table>

GRE (Graduate Record Examinations) | Required.*

English Proficiency Test | Every applicant whose native language is not English or whose undergraduate instruction was not in English must provide an English proficiency test score and meet the Graduate School minimum requirements (https://grad.wisc.edu/apply/requirements/#english-proficiency).

Other Test(s) (e.g., GMAT, MCAT) | n/a

Letters of Recommendation Required | 3

* Except for current UW-Madison NE/EP/EMA undergraduate students.

The Graduate School sets minimum requirements for admissions (https://grad.wisc.edu/admissions/requirements/). Academic program admission requirements are often more rigorous than those set by the Graduate School. Please check the program website (https://www. engr.wisc.edu/department/engineering-physics/academics/ms-engineering-mechanics/) for details and admissions deadlines.

Funding

Graduate School Resources

Resources to help you afford graduate study might include assistantships, fellowships, traineeships, and financial aid. Further funding information (https://grad.wisc.edu/funding/) is available from the Graduate School. Be sure to check with your program for individual policies and restrictions related to funding.

Program Resources

Offers of financial support from the Department, College, and University are in the form of research assistantships (RAs), teaching assistantships (TAs), project assistantships (PAs), and partial or full fellowships. Prospective PhD students that receive such offers will have a minimum five-year guarantee of support. The funding for RAs comes from faculty research grants. Each professor decides on his or her own RA offers, and a portion of the top domestic applicants is invited to visit Madison in order to meet faculty members and tour the department facilities. International applicants must secure an RA, TA, PA, fellowship, or independent funding before admission is final. Funded students are expected to maintain full-time enrollment. See the program website (https://www. engr.wisc.edu/department/engineering-physics/academics/ms-engineering-mechanics/) for additional information.

Requirements

Minimum Graduate School Requirements

Review the Graduate School minimum academic progress and degree requirements (http://guide.wisc.edu/graduate/#policiesandrequirements), in addition to the program requirements listed below.
MAJOR REQUIREMENTS

MODE OF INSTRUCTION

<table>
<thead>
<tr>
<th>Face to Face</th>
<th>Evening/Weekend</th>
<th>Online</th>
<th>Hybrid</th>
<th>Accelerated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Mode of Instruction Definitions

**Evening/Weekend:** These programs are offered in an evening and/or weekend format to accommodate working schedules. Enjoy the advantages of on-campus courses and personal connections, while keeping your day job. For more information about the meeting schedule of a specific program, contact the program.

**Online:** These programs are offered primarily online. Many available online programs can be completed almost entirely online with all online programs offering at least 50 percent or more of the program work online. Some online programs have an on-campus component that is often designed to accommodate working schedules. Take advantage of the convenience of online learning while participating in a rich, interactive learning environment. For more information about the online nature of a specific program, contact the program.

**Hybrid:** These programs have innovative curricula that combine on-campus and online formats. Most hybrid programs are completed on-campus with a partial or completely online semester. For more information about the hybrid schedule of a specific program, contact the program.

**Accelerated:** These on-campus programs are offered in an accelerated format that allows you to complete your program in a condensed time-frame. Enjoy the advantages of on-campus courses with minimal disruption to your career. For more information about the accelerated nature of a specific program, contact the program.

CURRICULAR REQUIREMENTS

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>60 credits</td>
</tr>
<tr>
<td>Credit</td>
<td></td>
</tr>
</tbody>
</table>

| Minimum      | 32 credits |
| Residence    |         |

| Minimum Graduate Coursework | 30 of the required 60 credits must be in graduate-level coursework; courses with the Graduate Level Coursework attribute are identified and searchable in the university’s Course Guide (http://my.wisc.edu/CourseGuideRedirect/BrowseByTitle). In addition, at least 18 of the non-research credits must be in classes having the graduate-level designation. |

| Overall Graduate GPA Requirement | 3.00 GPA required. |

| Other Grade Requirements | Courses in which grades of BC, C, or below are received cannot be counted toward the degree except as follows: 1) Credits of C will be allowed provided they are balanced by twice as many credits of A or by four times as many credits of AB, 2) Credits of BC will be allowed provided they are balanced by twice as many credits of AB or by an equal number of credits of A. |

REQUISITED COURSES

At least 36 of the required 60 credits must be in classes satisfying the following general requirements and mathematics, breadth and depth requirements.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>E M A / CIV ENGR/ M E 508</td>
<td>Composite Materials</td>
<td>21</td>
</tr>
<tr>
<td>E M A 519</td>
<td>Fracture Mechanics</td>
<td></td>
</tr>
<tr>
<td>E M A 522</td>
<td>Aerodynamics Lab</td>
<td></td>
</tr>
<tr>
<td>E M A 523</td>
<td>Flight Dynamics and Control</td>
<td></td>
</tr>
<tr>
<td>E M A / M E 540</td>
<td>Experimental Vibration and Dynamic System Analysis</td>
<td></td>
</tr>
<tr>
<td>E M A / M S &amp; E 541</td>
<td>Heterogeneous and Multiphase Materials</td>
<td></td>
</tr>
<tr>
<td>E M A / E P 547</td>
<td>Engineering Analysis I</td>
<td></td>
</tr>
<tr>
<td>E M A / E P 548</td>
<td>Engineering Analysis II</td>
<td></td>
</tr>
<tr>
<td>E M A / M E 570</td>
<td>Experimental Mechanics</td>
<td></td>
</tr>
</tbody>
</table>

Mathematics Requirements

At least 6 credits (2 courses) must be in applied mathematics from the following list:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>E M A / E P 547</td>
<td>Engineering Analysis I</td>
</tr>
<tr>
<td>E M A / E P 548</td>
<td>Engineering Analysis II</td>
</tr>
<tr>
<td>MATH 519</td>
<td>Ordinary Differential Equations</td>
</tr>
<tr>
<td>MATH 521</td>
<td>Analysis I</td>
</tr>
<tr>
<td>MATH 522</td>
<td>Analysis II</td>
</tr>
<tr>
<td>MATH 540</td>
<td>Linear Algebra II</td>
</tr>
<tr>
<td>MATH 619</td>
<td>Analysis of Partial Differential Equations</td>
</tr>
</tbody>
</table>
MATH 623  Complex Analysis
MATH 703  Methods of Applied Mathematics 1
MATH 704  Methods of Applied Mathematics-2
MATH/COMP SCI 714  Methods of Computational Mathematics I
MATH/COMP SCI 715  Methods of Computational Mathematics II

**Breadth Requirement**
As part of their M.S. or Ph.D., students must have taken courses from at least 2 of the 3 areas defined below. For each of the 2 areas, the student must have taken at least 2 courses. The courses must be at a similar level to those listed below.

**Solid Mechanics**
- EMA 506  Advanced Mechanics of Materials I 3
- EMA/CIV ENGR/M E 508  Composite Materials 3
- EMA 519  Fracture Mechanics 3
- EMA/M S & E 541  Heterogeneous and Multiphase Materials 3
- EMA 570  Introduction to Finite Elements 3
- EMA 611  Advanced Mechanical Testing of Materials 3
- EMA/E P 615  Micro- and Nanoscale Mechanics 3
- EMA 622  Mechanics of Continua 3
- EMA 630  Viscoelastic Solids 3
- EMA 700  Theory of Elasticity 3
- EMA/A/M E 703  Plasticity Theory and Physics 3
- EMA 705  Advanced Topics in Finite Elements 3
- EMA/A/M E 706  Plates, Shells and Pressure Vessels 3
- EMA/A/M E 708  Advanced Composite Materials 3
- EMA/A/M E 722  Introduction to Polymer Rheology 3
- M/E/B M E 603  Topics in Bio-Medical Engineering (Topic: FE for Biomechanics) 1-3
- M E 753  Friction, Lubrication and Wear 3

**Fluid Mechanics**
- EMA 521  Aerodynamics 3
- EMA 622  Mechanics of Continua 3
- M E 563  Intermediate Fluid Dynamics 3
- M E 572  Intermediate Gas Dynamics 3
- M E 573  Computational Fluid Dynamics 3
- M E 769  Combustion Processes 3
- M E 770  Advanced Experimental Instrumentation 3
- M E 774  Chem Kinetics of Combust Systems 3
- M E 775  Turbulent Heat and Momentum Transfer 3
- MATH 705  Mathematical Fluid Dynamics 3

**Dynamics**
- EMA 523  Flight Dynamics and Control 3
- EMA/A/M E 540  Experimental Vibration and Dynamic System Analysis 3
- EMA 542  Advanced Dynamics 3
- EMA 545  Mechanical Vibrations 3
- EMA/ASTRON 550  Astrodynamics 3
- EMA 610  Structural Finite Element Model Validation 3
- EMA 642  Satellite Dynamics 3
- EMA 742  Theory and Applications in Advanced Dynamics 3
- EMA 745  Advanced Methods in Structural Dynamics 3
- EMA 747  Nonlinear and Random Mechanical Vibrations 3
- M/E C E 577  Automatic Controls Laboratory 4
- M E 740  Advanced Vibrations 3
- M E 747  Advanced Computer Control of Machines and Processes 3
- M E 748  Optimum Design of Mechanical Elements and Systems 3

**Depth Requirement**
At least 4 courses (12 credits) must be 700-level or above in mechanics, applied mathematics, or computer science. At least 2 of the courses (6 credits) must be from List 1 (below), and the remaining 2 courses (6 credits) may be from List 1 or List 2.

**List 1**
- Any EMA course except EMA 790, EMA 890, or EMA 990.
- EMA 601  Special Topics courses may only be counted as 700-level if designated as such by the instructor.
- CBE 720  Microhydrodynamics, Brownian Motion, and Complex Fluids
- CIV ENGR/G L E 730  Engineering Properties of Soils
- CIV ENGR/G L E 735  Soil Dynamics
- MATH 705  Mathematical Fluid Dynamics
- M E 740  Advanced Vibrations
- M E 746  Dynamics of Controlled Systems
- M E 747  Advanced Computer Control of Machines and Processes
- M E 748  Optimum Design of Mechanical Elements and Systems
- M E 751  Advanced Computational Dynamics
- M E 753  Friction, Lubrication and Wear
- M E 769  Combustion Processes
- M E 770  Advanced Experimental Instrumentation
- M E 774  Chem Kinetics of Combust Systems
- M E 775  Turbulent Heat and Momentum Transfer

**List 2**
- COMP SCI/MATH 714  Methods of Computational Mathematics I
- COMP SCI/MATH 715  Methods of Computational Mathematics II
- COMP SCI 733  Computational Methods for Large Sparse Systems
Policies

GRADUATE SCHOOL POLICIES

The Graduate School’s Academic Policies and Procedures (https://grad.wisc.edu/acadpolicy/) provide essential information regarding general university policies. Program authority to set degree policies beyond the minimum required by the Graduate School lies with the degree program faculty. Policies set by the academic degree program can be found below.

PRIOR COURSEWORK

GRADUATE WORK FROM OTHER INSTITUTIONS

With permission from the faculty advisor and the department chair, students may use up to 6 credits of graduate work taken at another institution if they meet departmental MS requirements. Coursework earned ten or more years prior to admission to the PhD program is not allowed to satisfy requirements.

GRADUATE COURSEWORK FROM PREVIOUS MS

With advisor and EP Graduate Studies Committee approval, students may use up to 15 credits of prior MS coursework toward the PhD, provided that all of the following are met: (1) The student has completed an MS degree in a relevant field. (2) The coursework proposed by the student is at the graduate level and was taken as part of the student’s completed MS program. (3) The student’s faculty advisor agrees that the prior coursework proposed by the student satisfies the Engineering Mechanics PhD program requirements in terms of subject area and rigor. (4) A member of the EP Graduate Studies Committee who is familiar with the EM PhD program confirms the advisor’s recommendation.

UW–MADISON UNDERGRADUATE

With faculty approval, students who have received their undergraduate degree from UW–Madison may apply up to 7 credits numbered 400 or above toward the minimum graduate degree credit requirement. This work would not be allowed to count toward the 50% graduate coursework minimum unless taken at the 700 level or above. No credits can be counted toward the minimum graduate residence credit requirement. No credits can be counted toward the minimum graduate residence credit requirement. Coursework earned ten years or more prior to admission to the PhD program is not allowed to satisfy requirements.

UW–MADISON UNIVERSITY SPECIAL

With program approval, students are allowed to count up to 15 credits of coursework numbered 400 or above taken as a UW–Madison Special student toward the minimum graduate residence credit requirement, and the minimum graduate degree credit requirement. UW–Madison coursework taken as a University Special student would not be allowed to count toward the 50% graduate coursework minimum unless taken at the 700 level or above. Coursework earned ten years or more prior to admission to a doctoral degree is not allowed to satisfy requirements.

PROBATION

A semester GPA below 3.0 will result in the student being placed on academic probation. If a semester GPA of 3.0 is not attained during the subsequent semester of full time enrollment (or 12 credits of enrollment if enrolled part-time) the student may be dismissed from the program or
allowed to continue for one additional semester based on advisor appeal to the Graduate School.

**ADVISOR / COMMITTEE**

Each student is required to meet with their advisor prior to registration every semester.

**CREDITS PER TERM ALLOWED**

15 credits

**TIME CONSTRAINTS**

The Ph.D. qualifying examination should be first taken no later than completion of the M.S. requirements, or the beginning of the fifth semester of graduate study, whichever comes first. Students entering the program with a master’s degree in EMA, EP or NE from another institution, and taking the qualifying exam in that same major, must take the exam by the beginning of their third semester.

Students must submit the doctoral plan of study one month before the end of the semester following the one in which the qualifying exam is passed.

Candidates are expected to pass the Ph.D. preliminary examination no later than the end of the third year of graduate study, or by the end of the second regular semester following the one in which the Ph.D. qualifying examination was passed, whichever is later. A candidate who fails to take the preliminary examination within four years of passing the qualifying examination must retake the qualifying examination.

An oral examination on the findings of the Ph.D. research is required at the end of the thesis work. The candidate must apply for a warrant from the Graduate School through the student services office at least three weeks prior to the oral examination. The final oral examination must be taken within five years of passing the preliminary examination.

**GRIEVANCES AND APPEALS**

These resources may be helpful in addressing your concerns:

- Bias or Hate Reporting (https://doso.students.wisc.edu/bias-or-hate-reporting/)
- Graduate Assistantship Policies and Procedures (https://hr.wisc.edu/policies/gapp/#grievance-procedure)
- Hostile and Intimidating Behavior Policies and Procedures (https://hr.wisc.edu/hib/)
- Office of the Provost for Faculty and Staff Affairs (https://facstaff.provost.wisc.edu/)
- Dean of Students Office (https://doso.students.wisc.edu/) (for all students to seek grievance assistance and support)
- Employee Assistance (http://www.eao.wisc.edu/) (for personal counseling and workplace consultation around communication and conflict involving graduate assistants and other employees, post-doctoral students, faculty and staff)
- Employee Disability Resource Office (https://employedisabilities.wisc.edu/) (for qualified employees or applicants with disabilities to have equal employment opportunities)
- Graduate School (https://grad.wisc.edu/) (for informal advice at any level of review and for official appeals of program/departmental or school/college grievance decisions)
- Office of Compliance (https://compliance.wisc.edu/) (for class harassment and discrimination, including sexual harassment and sexual violence)
- Office of Student Conduct and Community Standards (https://conduct.students.wisc.edu/) (for conflicts involving students)
- Ombuds Office for Faculty and Staff (http://www.ombuds.wisc.edu/) (for employed graduate students and post-docs, as well as faculty and staff)
- Title IX (https://compliance.wisc.edu/titleix/) (for concerns about discrimination)

**Engineering Mechanics Grievance Procedures**

Students who feel that they have been treated unfairly have the right to a prompt hearing of their grievance. Such complaints may involve course grades, classroom treatment, advising, various forms of harassment, or other issues. Any student or potential student may use these procedures.

- The student should speak first with the person toward whom the grievance is directed. In most cases, grievances can be resolved at this level.
- Should a satisfactory resolution not be achieved, the student should contact the program’s Grievance Advisor to discuss the grievance. The Graduate Student Coordinator can provide students with the name of this faculty member, who facilitates problem resolution through informal channels. The Grievance Advisor is responsible for facilitating any complaints or issues of students. The Grievance Advisor first attempts to help students informally address the grievance prior to any formal complaint. Students are also encouraged to talk with their faculty advisors regarding concerns or difficulties if necessary. University resources for sexual harassment concerns can be found on the UW Office of Equity and Diversity website.
- If the issue is not resolved to the student’s satisfaction, the student can submit the grievance to the Grievance Advisor in writing, within 60 calendar days of the alleged unfair treatment.
- On receipt of a written complaint, a faculty committee will be convened by the Grievance Advisor to manage the grievance. The program faculty committee will obtain a written response from the person toward whom the complaint is directed. The response will be shared with the person filing the grievance.
- The faculty committee will determine a decision regarding the grievance. The Grievance Advisor will report on the action taken by the committee in writing to both the student and the party toward whom the complaint was directed within 15 working days from the date the complaint was received.
- At this point, if either party (the student or the person toward whom the grievance is directed) is unsatisfied with the decision of the faculty committee, the party may file a written appeal. Either party has 10 working days to file a written appeal to the College of Engineering.

The Assistant Dean for Graduate Affairs (engr-dean-graduateaffairs@engr.wisc.edu) provides overall leadership for graduate education in the College of Engineering (CoE) and is a point of contact for graduate students who have concerns about education, mentoring, research, or other difficulties.

The Graduate School has procedures for students wishing to appeal a grievance decision made at the college level. These policies are described in the Academic Policies and Procedures at https://grad.wisc.edu/academic-policies/.
PROFESSIONAL DEVELOPMENT

GRADUATE SCHOOL RESOURCES
Take advantage of the Graduate School's professional development resources (https://grad.wisc.edu/pd/) to build skills, thrive academically, and launch your career.

LEARNING OUTCOMES

1. Demonstrate an extraordinary, deep understanding of mathematical, scientific, and engineering principles in the field.
2. Demonstrate an ability to formulate, analyze, and independently solve advanced engineering problems.
3. Apply the relevant scientific and technological advancements, techniques, and engineering tools to address these problems.
4. Recognize and apply principles of ethical and professional conduct.
5. Demonstrate an ability to synthesize knowledge from a subset of the biological, physical, and/or social sciences to help frame problems critical to the future of their discipline.
6. Demonstrate an ability to conduct original research and communicate it to their peers.

PEOPLE

FACULTY

PROFESSORS
Blanchard, Bonazza, Bronkhorst, Crone, Hegna, Henderson, Lakes, Schmitz, Smith, Sovinec, Sridharan, Waleffe, Wilson (chair)

ASSOCIATE PROFESSORS
Allen, Witt

ASSISTANT PROFESSORS
Choy, Couet, Geiger, Franck, Notbohm, Thevamaran, Zhang

AFFILIATE PROFESSORS
Anderson, Bednarz, Bier, Engle, Graham, Kolkowitz, Ludois, Ma, Miller, Morgan, Nellis, Pfotenhauer, Porter, Prabhakar, Robertson, Szlufarska, Thoma, Thomadsen, Trujillo, Vanderby

EMERITUS PROFESSORS
Abdel-Khalik, T. Allen, Bisognano, Callen, Carbon, Conrad, Cook, Corradini, DeLuca, Drugan, Emmert, Fonck, Hershkowitz, Kammer, Kulcinski, Mackie, Malkus, Moses, Plesha, Sandor, Schlack