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

* a) Current UW-Madison NE/EP/EMA undergraduate students are not required to submit GRE scores.
   b) Due to COVID-19, GRE scores are not required for all applications to Engineering Mechanics graduate programs for the Spring 2022 term.

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/
MAJOR REQUIREMENTS

MODE OF INSTRUCTION

<table>
<thead>
<tr>
<th></th>
<th>Face to Face</th>
<th>Evening/Weekend</th>
<th>Online</th>
<th>Hybrid</th>
<th>Accelerated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode of Instruction Definitions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accelerated: Accelerated programs are offered at a fast pace that condenses the time to completion. Students are able to complete a program with minimal disruptions to careers and other commitments.</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Evening/Weekend: Courses meet on the UW-Madison campus only in evenings and/or on weekends to accommodate typical business schedules. Students have the advantages of face-to-face courses with the flexibility to keep work and other life commitments.</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Face-to-Face: Courses typically meet during weekdays on the UW-Madison Campus.</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Hybrid: These programs combine face-to-face and online learning formats. Contact the program for more specific information.</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Online: These programs are offered 100% online. Some programs may require an on-campus orientation or residency experience, but the courses will be facilitated in an online format.</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

CURRICULAR REQUIREMENTS

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Credit Requirement</td>
<td>60 credits</td>
</tr>
<tr>
<td>Minimum Residence Credit Requirement</td>
<td>32 credits</td>
</tr>
<tr>
<td>Minimum Graduate Coursework Requirement</td>
<td>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 (<a href="https://registrar.wisc.edu/course-guide/">https://registrar.wisc.edu/course-guide/</a>). In addition, at least 18 of the non-research credits must be in classes having the graduate-level designation.</td>
</tr>
<tr>
<td>Overall Graduate GPA Requirement</td>
<td>3.00 GPA required.</td>
</tr>
<tr>
<td>Other Grade Requirements</td>
<td>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.</td>
</tr>
<tr>
<td>Assessments and Examinations</td>
<td>Ph.D. qualifying examination is required of all students. After acceptance of the student’s doctoral plan of study, the student must take an oral preliminary examination. Final oral examination is required at the end of the thesis work.</td>
</tr>
</tbody>
</table>

REQUIRED 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>
<tr>
<td>MATH 623</td>
<td>Complex Analysis</td>
</tr>
<tr>
<td>MATH 703</td>
<td>Methods of Applied Mathematics 1</td>
</tr>
<tr>
<td>MATH 704</td>
<td>Methods of Applied Mathematics 2</td>
</tr>
<tr>
<td>MATH/ COMP SCI 714</td>
<td>Methods of Computational Mathematics I</td>
</tr>
<tr>
<td>MATH/ COMP SCI 715</td>
<td>Methods of Computational Mathematics II</td>
</tr>
</tbody>
</table>
### 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/ME 508 Composite Materials (3)
- EMA 519 Fracture Mechanics (3)
- EMA/CIV ENGR/MES&E 541 Heterogeneous and Multiphase Materials (3)
- EMA 570 Experimental Mechanics (3)
- EMA 611 Advanced Mechanical Testing of Materials (3)
- EMA/EPI 615 Micro- and Nanoscale Mechanics (3)
- EMA 622 Mechanics of Continua (3)
- EMA 630 Viscoelastic Solids (3)
- EMA 700 Theory of Elasticity (3)
- EMA ME 703 Plasticity Theory and Physics (3)
- EMA ME 705 Advanced Topics in Finite Elements (3)
- EMA ME 706 Plates, Shells and Pressure Vessels (3)
- EMA ME 708 Advanced Composite Materials (3)
- EMA ME 722 Introduction to Polymer Rheology (3)
- MEBME 603 Topics in Bio-Medical Engineering (3)
- MEBME 753 Friction, Lubrication and Wear (3)

#### Fluid Mechanics
- EMA 521 Aerodynamics (3)
- EMA 622 Mechanics of Continua (3)
- EMA 563 Intermediate Fluid Dynamics (3)
- EMA 572 Intermediate Gas Dynamics (3)
- EMA 573 Computational Fluid Dynamics (3)
- EMA 729 Turbulent Flow Analysis (3)
- EMA 770 Advanced Experimental Instrumentation (3)
- MEBME 734 Chem Kinetics of Combust Systems (3)
- MEBME 775 Turbulent Heat and Momentum Transfer (3)
- MATH 705 Mathematical Fluid Dynamics (3)

#### Dynamics
- EMA 523 Flight Dynamics and Control (3)
- EMA/ME 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)
- MEBME 740 Advanced Vibrations (3)
- MEBME 747 Advanced Computer Control of Machines and Processes (3)
- MEBME 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/GLE 730 Engineering Properties of Soils
- CIV ENGR/GLE 735 Soil Dynamics
- MATH 705 Mathematical Fluid Dynamics
- MEBME 740 Advanced Vibrations
- MEBME 746 Dynamics of Controlled Systems
- MEBME 747 Advanced Computer Control of Machines and Processes
- MEBME 748 Optimum Design of Mechanical Elements and Systems
- MEBME 751 Advanced Computational Dynamics
- MEBME 753 Friction, Lubrication and Wear
- MEBME 758 Combustion Processes
- MEBME 770 Advanced Experimental Instrumentation
- MEBME 774 Chem Kinetics of Combust Systems
- MEBME/CIV ENGR/EMA 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
- COMP SCI 760 Machine Learning
- ECE 717 Linear Systems
- ECE 719 Optimal Systems
- ECE/COMP SCI 761 Mathematical Foundations of Machine Learning
- ECE/CBE/MATH 777 Nonlinear Dynamics, Bifurcations and Chaos
E C E / C O M P S C I / S T A T 861  Theoretical Foundations of Machine Learning
M A T H 703  Methods of Applied Mathematics 1
M A T H 704  Methods of Applied Mathematics 2
M E 714  Advanced Materials Processing and Manufacturing
M E 718  Modeling and Simulation in Polymer Processing
M E / E C E 739  Advanced Robotics
M E 758  Solid Modeling
M E 761  Topics in Thermodynamics
M E 764  Advanced Heat Transfer I - Conduction
M S & E 748  Structural Analysis of Materials
M S & E 750  Imperfections and Mechanical Properties
M S & E 760  Molecular Dynamics and Monte Carlo Simulations in Materials Science
P H Y S I C S 711  Theoretical Physics - Dynamics
P H Y S I C S 715  Statistical Mechanics
P H Y S I C S 721  Theoretical Physics - Electrodynamics
P H Y S I C S 731  Quantum Mechanics
P H Y S I C S 732  Quantum Mechanics
P H Y S I C S 751  Advanced Solid State Physics
P H Y S I C S 801  Special Topics in Theoretical Physics (when taught as Nanostructures in Science and Technology)

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.

1 All credits earned toward the EM MS degree at the University of Wisconsin-Madison count toward the EM PhD program. This policy applies to students who have not completed a previous MS degree in a relevant field.

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. Coursework earned ten years or more prior to admission to a PhD program is not allowed to satisfy requirements.

With faculty approval, students who have received an ABET-accredited undergraduate degree (not including UW-Madison) may be eligible to apply up to 7 credits of their undergraduate coursework toward the Minimum Graduate Degree Credit Requirement. No credits can be counted toward the Minimum Graduate Residence Credit Requirement, nor the Minimum Graduate Coursework (50%) Requirement. Coursework earned five or more years prior to admission to a master’s degree 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 exam. 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://employeedisabilities.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/.

OTHER

n/a
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
Paul Wilson (Chair)
Matt Allen
Riccardo Bonazza
Curt A. Bronkhorst
Wendy Crone
Chris Hegna
Douglass Henderson
Roderic Lakes
Oliver Schmitz
Carl Sovinec
Kumar Sridharan
Fabian Waleffe

ASSISTANT PROFESSORS
Jennifer Choy
Adrien Couet
Stephanie Diem
Jennifer Franck
Benedikt Geiger
Ben Lindley
Jacob Notbohm
Ramathasan Thevamaran
Yongfeng Zhang

See also Engineering Physics Faculty Directory (https://directory.engr.wisc.edu/ep/faculty/).