ENGINEERING SCIENCE AND MECHANICS

Graduate Program Head
Albert Segall

Program Code
EMCH (M.Eng.); ESMCH (Ph.D., M.S.)

Campus(es)
University Park (Ph.D., M.S., M.Eng.)

Degrees Conferred
Doctor of Philosophy (Ph.D.)
Master of Science (M.S.)
Master of Engineering (M.Eng.) in Engineering Mechanics
Integrated B.S. in Engineering Science and M.S. in Engineering Science and Mechanics
Joint M.D./Ph.D. with the College of Medicine

The Graduate Faculty
View (https://secure.gradsch.psu.edu/gpms/?searchType=fac&prog=ESMCH)

Opportunities for graduate studies are available in interdisciplinary and multidisciplinary research areas including:

• Multiscale, multiphysical computational modeling and simulation
• Data Science AI, machine learning
• Brain Science, neural engineering, neuroethics
• Structural and health monitoring
• Advanced materials
  • elastodynamic metamaterials
  • electronic materials
  • twisted 2D materials
  • bioengineered materials
• Materials characterization
  • In-situ microscopy in extreme environments
  • Ultrasonic nondestructive evaluation
• Additive manufacturing
• Micro and nanomechanics
• Biomechanics and mechanobiology
• Quantum computation and information science
• Optoelectronics, nanophotonics, and lasers
• Dynamic systems, acoustics, and vibrations
• Emerging manufacturing process for materials, tissues, and devices
• Bionanoscience, biomedical electronics and devices
• Smart sensors
  • Flexible and stretchable biosensors
  • Label-free biosensors
  • Quantum sensors

Admission Requirements
Applicants apply for admission to the program via the Graduate School application for admission (http://gradschool.psu.edu/prospective-students/how-to-apply/). Requirements listed here are in addition to Graduate Council policies listed under GCAC-700 Professional Degree Policies (http://gradschool.psu.edu/graduate-education-policies/).

At least 31 credits at the 400, 500, or 800 must be earned, with at least 18 at the 500 or 800 level, and at least 6 at the 500 level. Of these, 22 must be from lecture/laboratory courses approved by the department.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESC 514</td>
<td>Engineering Science and Mechanics Seminar</td>
<td>1</td>
</tr>
<tr>
<td>or EMCH 514</td>
<td>Engineering Science and Mechanics Seminar</td>
<td></td>
</tr>
<tr>
<td>Select 3 credits in each of the following areas:</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Analysis</td>
<td>Fields</td>
<td></td>
</tr>
<tr>
<td>Motion</td>
<td>Materials Performance/Reliability or Materials Processing/Structure/Characterization</td>
<td>3</td>
</tr>
<tr>
<td>Select 3 additional credits from any one of the four categories above</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Electives</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>ESC 596</td>
<td>Individual Studies</td>
<td>3</td>
</tr>
<tr>
<td>or EMCH 596</td>
<td>Individual Studies</td>
<td></td>
</tr>
<tr>
<td>Total Credits</td>
<td></td>
<td>31</td>
</tr>
</tbody>
</table>

A scholarly written report on a developmental study involving at least one area represented in the course work must be written while enrolled in either ESC 596 or EMCH 596. This scholarly paper should reflect the high quality of research required to meet the Engineering Science and Mechanics M.Eng. degree standards, as determined by the ESM Graduate Officer and the ESM Graduate Curriculum Committee.

A 3.0 minimum grade point average is required to maintain good academic standing and for graduation.

Master of Science (M.S.)
Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (http://gradschool.psu.edu/graduate-education-policies/)
**Thesis Track**
At least 32 credits at the 400, 500, 600, or 800 level must be earned, with at least 18 credits at the 500 and 600 levels combined, and 24 credits must be from 400- and 500-level lecture/laboratory courses approved by the department. No more than 6 credits may be earned from 400-level courses.

A thesis is required and at least 6 credits of thesis research must be included in the student’s program of study. The thesis must be a well-organized account of research undertaken by the student and must show initiative and originality. The thesis must be accepted by the advisers and/or committee members, the head of the graduate program, and the Graduate School, and the student must pass a thesis defense.

A 3.0 minimum grade-point average is required to maintain good academic standing and for graduation.

**Non-Thesis Track**
At least 32 credits at the 400, 500, 600, or 800 level must be earned, with at least 18 credits at the 500 level, and 27 credits must be from 400- and 500-level lecture/laboratory courses approved by the department. No more than 6 credits may be earned from 400-level courses.

A student must earn at least 27 course credits in 400- and 500-level lecture/laboratory courses approved by the department, and 5 credits in a graduate seminar (EMCH 514 or ESC 514). No more than 6 of the 27 course credits can be in 400-level courses. As part of the 27 course credits, at least 3 will be in an advanced mathematics course (EMCH 524A or equivalent). Furthermore, at least one course (of at least 3 credits each) must be taken from each of the following categories: Mechanics, Materials, and Engineering Science (a list of the courses in these categories is provided in the Guide to the Engineering Science and Mechanics Department). A minimum of 15 course credits must be in the major (courses with EMCH and/or ESC prefixes).

Requirements listed here are in addition to requirements listed in GCAC-200 Integrated Undergraduate-Graduate (IUG) Degree Programs (http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-210-integrated-undergraduate-graduate-degree-programs/).
The flexibility and strength in fundamentals of the Engineering Science curriculum provides an opportunity for Engineering Science undergraduate students to participate in the ESM Integrated Undergraduate Graduate (IUG) program. The IUG program promotes the interchange of ideas across all branches of the scientific and engineering disciplines from both a theoretical and experimental perspective. Students in the integrated degree program are expected to pursue interdisciplinary studies in areas that encompass nano- and bionanotechnology, advanced materials, electromagnetic, mechanics, microelectronics, nanoelectronics and bioelectronics, neural engineering, photonics and photovoltaics (among others) and they are expected to embrace multidisciplinary perspectives across departmental, College, and University boundaries.

Applicants apply for admission to the program via the Graduate School application for admission (http://gradschool.psu.edu/prospective-students/how-to-apply/). Requirements listed here are in addition to Graduate Council policies listed under GCAC-300 Admissions Policies (http://gradschool.psu.edu/graduate-education-policies/).

Application for IUG status may be made in the fifth or subsequent semesters. Students must apply to the program via the Graduate School application for admission (http://www.gradschool.psu.edu/prospective-students/how-to-apply/), and must meet all the admission requirements of the Graduate School and the Engineering Science and Mechanics graduate program for the Master of Science degree. Before applying to the Graduate School, students must have completed an entrance to their undergraduate major and have completed no less than 60 credits. Students must be admitted no later than the end of the second week of the semester preceding the semester of expected conferral of the undergraduate degree. Transfer students must have completed at least 15 credits at Penn State to enroll in an IUG.

In consultation with an adviser, students must prepare a plan of study appropriate to this integrated program, and must present their plan of study to the head of the graduate program or the appropriate committee overseeing the integrated program prior to being admitted to the program. The plan should cover the entire time period of the integrated program, and it should be reviewed periodically with an adviser as the student advances through the program.

Students must fulfill all requirements for each degree in order to be awarded that degree, subject to the double-counting of credits as outlined below. Degree requirements for the B.S. in Engineering Science are listed in the Undergraduate Bulletin (https://bulletins.psu.edu/undergraduate/). Degree requirements for the M.S. degree are listed on the Degree Requirements tab. If students accepted into the IUG program are unable to complete the M.S. degree, they are still eligible to receive their undergraduate degree if all the undergraduate degree requirements have been satisfied.

Students must sequence their courses so all undergraduate degree requirements are fulfilled before taking courses to count solely towards the graduate degree. Students are expected to complete the undergraduate degree requirements within the typical time to degree for the undergraduate major. In the semester in which the undergraduate degree requirements will be completed, IUG students must apply to graduate, and the undergraduate degree should be conferred at the next appropriate Commencement.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Courses Eligible to Double Count for Both Degrees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMCH 400</td>
<td>Advanced Strength of Materials and Design</td>
<td>3</td>
</tr>
</tbody>
</table>

Up to 12 credits may be double-counted towards the degree requirements for both the graduate and undergraduate degrees; a minimum of 50% of the double-counted courses must be at the 500 or 800 level. Independent study courses, the graduate thesis, and credits associated with the culminating experience for the graduate degree cannot be double-counted.

**Joint Degrees**

**Joint M.D./Ph.D. with the College of Medicine**

Requirements listed here are in addition to requirements listed in GCAC-211 Joint Degree Programs (http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-211-joint-degree-programs/).

**Admission Requirements**

All students must process an application via the American Medical College Application Service and be accepted for admission by the M.D./Ph.D. admissions committee. Admission to the program requires a minimum GPA of 3.5 and a Medical College Admission Test (MCAT) score of 32. Exceptions to the minimum requirements may be made at the discretion of the program for students with special backgrounds, abilities, and interests. Applicants will be accepted up to the number of places available for new students. Students must successfully complete Years M1 and M2 and Step 1 of the United States Medical Licensing Examination (USMLE) before entering the graduate degree program. All requirements for the Ph.D. degree must be completed prior to Year M3 of medical studies.

Students must apply to the Graduate School (http://www.gradschool.psu.edu/prospective-students/how-to-apply/) for admission to the graduate program. Applicants holding undergraduate degrees in engineering, the mathematical sciences, mathematics, engineering science, and materials science and engineering who present a minimum 3.5 grade-point average will be considered for admission. Exceptions to the minimum 3.5 grade-point average may be made at the discretion of the program for students with special backgrounds, abilities, and interests. Applicants will be accepted up to the number of places available for new students.

All program-specific documents for admission (e.g., transcripts, letters of recommendation, etc.) must be submitted by all applicants.

**Degree Requirements**

The Joint M.D./Ph.D. Program in Engineering Science and Mechanics (M.D./Ph.D., ESMCH) will form the basis for an interdisciplinary, transformational program that will educate a new generation of Physician Engineering Scientists, working at the forefronts of clinical and translational research. This Joint Degree Program responds to the national call to expedite the incorporation of clinical and translational research into improved healthcare.

Students in the Joint M.D./Ph.D. Program in Engineering Science and Mechanics will complete 4 years of medical studies (designated years M1 through M4) at the Medical School, College of Medicine, and 3 or more
years of Graduate Study (designated years G1 through G3 or GX) in the Engineering Science and Mechanics (ESM) Department.

Joint M.D./Ph.D. candidates should apply to the Ph.D. program in Engineering Science and Mechanics in M2. After successfully completing the first 2 years of medical school, including all required rotations and Step 1 of the United States Medical Licensing Examination (USMLE), the candidate will be admitted to the Ph.D. program in Engineering Science and Mechanics.

Students will complete all degree requirements for the Ph.D. Degree in Engineering Science and Mechanics, including SARI (Scholarship and Research Integrity) training for the Responsible Conduct of Research (RCR) that must be met by students admitted to the program with either a baccalaureate or a master's degree, with the following exceptions:

• if students accepted into the joint degree program are unable to complete the M.D. degree, they are still eligible to receive the Ph.D. degree if all Ph.D. requirements have been satisfied;
• students admitted to the program with a baccalaureate degree will be allowed to double count 9 professional credits toward graduate course credit for the Ph.D. degree; and,
• students admitted to the program with a master's degree will be allowed to double count 7 professional credits toward graduate course credit for the Ph.D. degree.

Students will complete all requirements for the M.D. Degree that must be met by students admitted to the program with either a baccalaureate or master's degree, with the following exceptions:

• baccalaureate degree holders will be allowed to double count 10 research credits (ESC 600/EMCH 610) toward professional credits for the M.D. degree; and,
• master's degree holders will be allowed to double count 5 research credits (ESC 600/EMCH 610) applied to the Ph.D. ESMCH degree toward professional credits for the M.D. degree.

Students may take the qualifying examination after completing 18 credits of approved graduate course work.

• master's degree holders accepted into the Joint M.D./Ph.D. program may take the qualifying examination in the Spring Semester of Year G1, but no later than the Fall Semester of G2.
• baccalaureate degree holders accepted into the Joint M.D./Ph.D. program may take the qualifying examination within 3 semesters of entry into the Ph.D. program (expected to be the Fall Semester of G2).

Following completion of the Ph.D. dissertation, students will return to medical school to complete Years M3 and M4 of the professional M.D. degree.

Minor
A graduate minor is available in any approved graduate major or dual-title program. The default requirements for a graduate minor are stated in Graduate Council policies listed under GCAC-600 Research Degree Policies (http://gradschool.psu.edu/graduate-education-policies/) and GCAC-700 Professional Degree Policies (http://gradschool.psu.edu/graduate-education-policies/), depending on the type of degree the student is pursuing:

• GCAC-611 Minor - Research Doctorate (https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-611-minor-research-doctorate/)
• GCAC-641 Minor - Research Master's (https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-641-minor-research-masters/)
• GCAC-709 Minor - Professional Doctorate (https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-700/gcac-709-professional-doctoral-minor/)
• GCAC-741 Minor - Professional Master's (https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-700/gcac-741-masters-minor-professional/)

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the Tuition & Funding (http://gradschool.psu.edu/graduate-funding/) section of The Graduate School's website. Students on graduate assistantships must adhere to the course load limits (http://gradschool.psu.edu/graduate-education-policies/gsad/gsad-900/gsad-901-graduate-assistants/) set by The Graduate School.

Research and Teaching Assistantships (half time) are granted to a majority of graduate students in good academic standing. Financial support is ordinarily limited to three semesters for full-time master's degree students, and six semesters for full-time Ph.D. students.

In addition to the fellowships, traineeships, graduate assistantships, or other forms of financial aid described in the link above, ESM has a number of scholarships that may provide graduate support. Students who wish to request consideration for these funds should notify the ESM Coordinator for Alumni, Development and Advancement in 212 Earth & Engineering Science Building.

Theodore Holden Thomas Jr., Memorial Scholarship
To provide financial assistance to undergraduate or graduate students who display outstanding ability and have enrolled in the Department of Engineering Science and Mechanics.

Sabih and Guler Hayek Graduate Scholarship in Engineering Science and Mechanics
To provide recognition and financial assistance to outstanding graduate students enrolled or planning to enroll in the Department of Engineering Science and Mechanics.

Dr. Richard Llorens Graduate Award in Engineering Science and Mechanics
To provide recognition and financial assistance to graduate students pursuing a degree in Engineering Science and Mechanics who have achieved academic excellence.

Richard P. McNitt Scholarship in Engineering Science and Mechanics
To provide financial assistance to undergraduate or graduate students enrolled in the Department of Engineering Science and Mechanics who have achieved superior academic records or who manifest promise of outstanding academic success.

DR. JOHN T. FRASIER GRADUATE FELLOWSHIP
To recruit and recognize outstanding students enrolled in a graduate degree offered by the Department of Engineering Science and Mechanics.

DR. JUDITH A. TODD COLEY AND DR. STEPHEN M. COLEY SCHOLARSHIP IN ENGINEERING SCIENCE AND MECHANICS
To provide recognition and financial assistance to outstanding graduate and undergraduate students enrolled or planning to enroll in a degree
program offered by the Department of Engineering Science and Mechanics.

DEPARTMENT OF ENGINEERING SCIENCE AND MECHANICS
GENERAL SCHOLARSHIP
To provide recognition and financial assistance to outstanding graduate and undergraduate students enrolled or planning to enroll in the Department of Engineering Science and Mechanics.

Courses
Graduate courses carry numbers from 500 to 699 and 800 to 899. Advanced undergraduate courses numbered between 400 and 499 may be used to meet some graduate degree requirements when taken by graduate students. Courses below the 400 level may not. A graduate student may register for or audit these courses in order to make up deficiencies or to fill in gaps in previous education but not to meet requirements for an advanced degree.

Engineering Mechanics (EMCH) Course List (https://bulletins.psu.edu/university-course-descriptions/graduate/emch/)

Learning Outcomes
1. Know: Graduates will demonstrate an in-depth knowledge of the core theories and methods within one or more sub-specialties in the fields of engineering science and mechanics. The core demonstration will include the application of physics, advanced mathematics and engineering principles to problems in mechanics, materials, bionanotechnology, nanoscience and neuroscience.
2. Create: Graduates will be able to synthesize theory, literature and experimental results to generate new concepts, designs or hypotheses in engineering science and mechanics.
3. Apply: Graduates will be able to carry out independent and original research studies that address current problems in the multi-disciplinary field of engineering science and mechanics.
4. Communicate: Graduates will be able to convey ideas or arguments in clear, concise, well organized papers and proposals as well as in formal, oral presentations.
5. Critical Thinking: Graduates will be able to critically analyze work by others in their field of specialty.
6. Professional Practice: Graduates will demonstrate the ability to collaborate in a collegial and ethical manner with other professionals within their field and/or with diverse scientific backgrounds.

Contact
Campus
University Park
Graduate Program Head
Albert Eliot Segall
Director of Graduate Studies (DGS) or Professor-in-Charge (PIC)
Albert Eliot Segall
Program Contact
Tammy L Coval
212 EES Building
Pennsylvania State University
University Park PA 16802
tlc21@psu.edu
(814) 863-4586
Program Website
View (http://www.esm.psu.edu/)