PennState
College of Engineering

The Pennsylvania State University
Department of Engineering Science and Mechanics
212 Earth and Engineering Sciences Building
University Park, PA 16802
(814) 865-4523

Engineering Science and Mechanics

Graduate Programs Guide

FALL 2024/SPRING 2025

Graduate Officer: Dr. Laura Cabrera
Graduate Programs Director: Dr. Elizabeth Sikora
Graduate Programs Coordinators: Mrs. Tammy Coval and Ms. Ashley Cecil

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ESM Academic Integrity Policy

The Department of Engineering Science and Mechanics at The Pennsylvania State University considers academic training to be apprenticeship for practice in the professions. Students are expected to demonstrate a code of moral integrity and ethical standards commensurate with the high expectations that society places upon professional practice. Accordingly, it is the policy of the department to maintain the highest standard of academic honesty and integrity.

Academic dishonesty includes, but is not limited to, cheating, copying on tests, plagiarizing **(copying anything without proper citation(s))**, acts of aiding or abetting, unauthorized possession of materials, tampering with work, ghosting, altering examinations and theft. Students are encouraged to report incidents of academic dishonesty to their instructors in order to promote a fair academic climate and an equal opportunity learning environment.

A student charged with academic dishonesty will be given oral or written notice of the charge by the instructor. A student contesting such charge may seek redress through informal discussions with the instructor(s), department head or college dean. If the instructor believes that the infraction is sufficiently serious to warrant referral to the Office of Conduct Standards, or if the instructor awards a final grade of F in the course because of the infraction, the student and instructor will be afforded formal, due process procedures governed by Penn State Senate Policy 49-20. Policy 49-20 and procedures can be found in the document *Policy and Rules for Students* issued annually by the Senate Office and available through each student's home department or college dean's office.

Academic Integrity policy information can also be found on the web at:

https://www.engr.psu.edu/faculty-staff/academic-integrity.aspx

ESM Inclusion Statement

Making Inclusive Research and Learning Environment a High-Quality Academic Experience for All Students

[Expectations for cultivating an inclusive environment.]

We, ESM department, are creating an environment promoting inclusion and diversity, consistent with expectations of STEM professionals. *We are* supporting the feeling of belonging for all participants. Each of us (students/staff/faculty) can make a deliberate effort to…

- participate in supporting inclusive exchanges amongst all participants in class, lab, group meetings;

- avoid any inappropriate actions or statements based on individual characteristics (such as age, religion, race, ethnicity, sexual orientation, gender identity, gender expression, marital status, nationality, political affiliation, ability status, educational background, or any other characteristic); and

- act in accordance with academic integrity while discouraging disruptive or harassing behavior (including, but not limited to, inappropriate or intimidating behavior and language, unwelcome jokes or comments, unwanted attention, offensive images, photography without permission, real or implied threat of harm).

Safer People Safer Places Network

Our department supports the Penn State Safer People Safer Places Network, and we are committed to creating and maintaining an open, safe, and inclusive environment honoring gender and sexual diversity. We can help you connect with resources on campus to address problems you may face that interfere with your academic and social success on campus as it relates to issues surrounding sexual and gender diversity.

For more information visit the Penn State Center for Sexual and Gender Diversity in LL011 HUB-Robeson Center or at: https://studentaffairs.psu.edu/csgd

Chapter 1: General Information

Graduate Study in Engineering Mechanics and in Engineering Science and Mechanics Degrees Awarded

Master of Engineering

Engineering Mechanics (M. ENG./EMCH)

Master of Science

Engineering Science and Mechanics (M.S./ESMCH) Thesis Track
Engineering Science and Mechanics (M.S./ESMCH) Non-Thesis Track
Engineering at the Nano-scale

Doctor of Philosophy

Engineering Science and Mechanics (Ph.D./ESMCH)

The Graduate Faculty

Opportunities for graduate studies are available in interdisciplinary and multidisciplinary research areas including: biomechanics; composite materials; continuum mechanics; electrical, magnetic, electromagnetic, optical, thermal, and mechanical properties of thin films.; experimental mechanics; lithography; microelectromechanical systems (MEMS) and micro-opto-electromechanical systems (MOEMS); micromechanics; molecular beam epitaxy; numerical methods; photovoltaic materials and devices; nanotechnology and nanobiotechnology; properties of materials; shock, vibration acoustics and nonlinear dynamics; structural health monitoring; structural mechanics; wave-material interactions and lasers; non-destructive evaluation and testing; wear and tribology; and forensic failure analysis. More information on specific research topics may be found under the faculty section of the ESM webpage (https://www.esm.psu.edu/department/faculty-list.aspx).

1.1 - Programs

Programs leading to M.ENG., M.S., and Ph.D. degrees allow specialization in research areas such as biomechanics; bionanotechnology; composite materials; fracture mechanics; continuum mechanics; electrical-magnetic-mechanical properties of thin films; experimental mechanics; MEMS; micromechanics; neural engineering; numerical methods; photovoltaic materials and devices; microelectronics materials and devices; nanotechnology; properties of materials, environmental degradation of materials, shock, vibration, acoustics and nonlinear dynamics; structural mechanics; wave/materials interactions; non-destructive evaluation; microfluidics; wear and tribology; neurosurgery, neuroscience and failure analysis.

The Master of Engineering degree in Engineering Mechanics is based primarily on graduate lecture course work. At least 30 credits of 400/500 level coursework must be completed by M.ENG. candidates for graduation. The student is also required to submit to the department a scholarly written report on a developmental study involving at least one area represented in his or her course work. This report must be comparable in the level of work and quality to a graduate thesis.

A student working for a Master of Science of Engineering Science and Mechanics may pursue either a thesis or a non-thesis track. For the Master of Science degree of Engineering Science and Mechanics, a minimum of 32 graduate credits (including 6 credits of thesis research) is required. A candidate for the Master of Science degree thesis track is required to submit a thesis to the University. A candidate for the Master of Science degree non-thesis track is required to submit a scholarly paper to the Department of Engineering Science and Mechanics.

For the Master of Science of Engineering at the Nanoscale, a minimum of 30 graduate credits (including 3 credits of research) is required. A candidate for the Master of Science of Engineering at the Nanoscale is required to submit a scholarly paper to the Department of Engineering Science and Mechanics.

The Ph.D. ESMCH degree is conferred in recognition of high attainment and productive scholarship. Students may enter the Ph.D. program after completing an M.S. degree or directly from the B.S. degree.

The minimum number of course credits required for students entering the PhD program with a baccalaureate degree is 27 course credits in 400- and 500- level lecture/laboratory courses approved by the department, 5 credits in a graduate seminar (E MCH/E SC 514), and 12 research credits.

Students entering with M.S. degree take 18 graduate course credits, 3 credits of seminar and a minimum of 6 and up to 12 research credits.

A student may be admitted to the Graduate School and the department to begin working toward a Ph.D.; however, he or she has no assurance of becoming a Ph.D. candidate until the qualifying examination has been passed and candidacy admission has been granted. The qualifying examination must be taken for the first time within two semesters of residency after completing a M.S. degree or 24 credits if starting with a B.S. degree.

After admission to the candidacy, Ph.D. students have their work supervised by a committee of the graduate faculty. This doctoral committee plays a major role in determining the candidate's specific course requirements. The committee also administers the candidate's comprehensive and final oral thesis examinations and guides the candidate's thesis work that must represent a significant contribution to the body of knowledge in a given area.

The Graduate School requires the student to have a high level of competence in the reading, writing, listening, and speaking of English before admission to candidacy. Proficiency is expected at the time of admission to the Graduate School.

Newly developed 3-credit course, ESC 515 Research Practices in Engineering is highly recommended as it will fulfil mandatory SARI requirements (see section 1.6) and is useful for gaining the research skills required for graduate studies.

1.2 - Admission

Students are admitted to the Graduate School by the University examiner, following favorable recommendation by the Graduate Officer and Graduate Admissions Committee. Procedures to be followed are outlined in the Penn State Graduate Degree Programs Bulletin.

A new policy was introduced effective July 5, 2012. HR 99 Background Check Process calls for all new hires to undergo a background check. New hires must complete the background check process before working for Penn State. One important new requirement is that "all individuals engaged by the University, including those engaged prior to, as of, or after, the effective date of this policy, to self-disclose criminal arrests and/or convictions as outlined in the Penn State Arrest and Conviction self-disclosure form within a 72-hour period of their occurrence" Please take the time to review the entire policy at http://guru.psu.edu/policies/OHR/hr99.html

The minimum departmental requirements for admission to graduate standing (for both master's and doctoral degrees) are:

A baccalaureate degree from an approved institution, either in an accredited engineering curriculum or in other programs in mathematics, the physical sciences, or engineering sciences is considered adequate to qualify the student for professional engineering activity.

The Engineering Science and Mechanics (ESM) Department has cooperative agreements with the undergraduate programs in Physics at the Millersville University of Pennsylvania, Edinboro University of Pennsylvania, Lock Haven University of Pennsylvania, Lebanon Valley College, and the Rose-Hulman Institute of Technology. *While these agreements do not guarantee acceptance into the graduate program, they do create a streamlined path for acceptance and transfer of undergraduate credits beyond those required for the B.S. degree*. Students who successfully complete a Bachelor of Science degree in Physics may elect to transfer up to 6 credits of 400-level courses in either physics or mathematics towards a Master of Science (M.S.) degree in the ESM Department ***provided the credits subject to transfer are above and beyond those required for the applicant's undergraduate degree.*** Such students may also undertake summer research in ESM for credit which may be applied towards the M.S. ESMCH degree. Undergraduate students from the ESM Department are strongly encouraged to consult with the ESM Graduate Officer during their junior year of studies; for complete admission details please contact the ESM Graduate Officer.

For regular admission, Engineering Science and Mechanics requires that a student's grade point average for the junior and senior undergraduate years must be 3.00 or better.

Provisional admission may be granted in special circumstances, i.e. baccalaureate degree not yet conferred, grades for the current semester not yet available, etc. Provisional admission is a temporary classification in which an applicant may remain for a period no longer than the first semester following admission, or the time it takes to accrue 15 credits, whichever comes first. Such admission is subject to cancellation if, upon arrival of the outstanding documents, the credentials do not meet the requirements for admission.

In some instances, credits may be transferred from a Penn State bachelor's program or from an external institution (see http://gradschool.psu.edu/current-students/transfer-credits/). Questions concerning credit transfers should be addressed to the ESM Graduate Officer.

The application procedure is described at http://www.esm.psu.edu/programs/graduate/application. The main part of the application must be submitted electronically (via the web), along with the current application fee of $65.00. Please check the value online as it may change. **Engineering Science students please contact the ESM department regarding the application fee. The following items must be uploaded through the online application process on the Graduate School Website:**

1. **One (1) <u>Official</u>** transcript of all previous college/university course work. International applicants must submit official records, or attested copies, with certified translations if the records are not in English; please note that notarized copies are not acceptable. **The official transcripts must be sent to The Graduate School, not to the department.**

2. Statement of Objectives: Tell us why you want to pursue an advanced degree in Engineering Science and Mechanics and how it will help you to further your career objectives. Usually, one page is sufficient.

3. General Graduate Record Examination (GRE) Aptitude Test scores are not required for admission.

4. The language of instruction at Penn State is English. English proficiency test scores (TOEFL/IELTS) are required for international applicants - Codes: PSU 2660, ESM 69 (official score report must be submitted by ETS®).

5. Three (3) letters of recommendation (on business or personal stationary with an authors' signature). ***We do not use recommendation forms***.

6. Application for Visa document (International students only): http://www.international.psu.edu/iss/pdf/VisaApp.pdf

1.3 - Scholarship

A minimum grade-point average of 3.00 for graduate work done at this University is required for graduation.

Grades are assigned solely on the basis of the instructor's judgment of the student's scholarly attainment. A "D" grade is considered a failing grade in a graduate course. While a "C" grade is considered passing, it is indicative of barely acceptable performance and may lower the GPA below the minimum grade-point average of 3.00 required for graduate work.

It is important to note that there are only three circumstances under which a course grade, once assigned, can be changed: (1) if there was a calculation or recording error on the instructor's part in the original grade assignment (Senate Policy 48-30), (2) if it is a course for which an R grade has been approved and in which an initial R can be assigned and changed later to a quality grade, or (3) if, as discussed below in section 1.5, a deferred grade (DF) was assigned and the deadline for course completion has not yet passed.

Students must maintain a minimum grade-point average of 3.00 to be eligible for a graduate assistant-ship or an instructorship. A graduate student with a grade-point average less than 3.00 is automatically put on academic probation and is required to meet the ESM Graduate Officer within two weeks of the notice.

Full-time master's degree students (including students receiving half-time support) should earn their degrees within two years; all required course work can be completed in 3 semesters. When available, financial support as a Teaching Assistant (TA) is ordinarily limited to no more than two semesters.

Students are expected to quickly find a thesis adviser and be supported as a Research Assistant (RA).

Full-time Ph.D. students (including students receiving half-time support) should earn their degrees in three years or less after successful completion of the qualifying examination; if they exceed this time period, financial support may be terminated. ***Students are expected to quickly find a thesis adviser and be supported as a Research Assistant (RA).***

1.4 - Registration

Continuous registration is required for all graduate students except for summers unless coursework, comprehensive exam, and/or a thesis defense is scheduled for the summer semester (so you need to be registered for it).

E MCH/E SC 601/611—This special registration may be used only by Ph.D. students starting with the semester after the comprehensive examination is passed. If a student must maintain full-time status for an assistantship, fellowship, bank loan, deferment, etc., 601 would be an appropriate registration. Students in 601 must devote their efforts entirely to thesis research and writing (i.e., no courses). Students registered for 601 may take up to three credits for audit with no additional charge or three credits for credit with an additional flat fee.

E MCH/E SC 600/610—If the students do not need to maintain full-time status, they should register for the appropriate number of thesis credits that accurately reflect the amount of research being done on the thesis (number of credits are to be determined in consultation with the student's adviser).

Graduate students may not drop a course without the approval of the academic adviser and the Graduate Officer. Students must satisfy the minimum course credit requirement to retain their assistantship as detailed on the "Terms of Offer."

1.5 - Deferred Grades

If work is incomplete at the end of a semester because of extenuating circumstances, the instructor may report Deferred (DF) in place of a grade, which will appear temporarily on the student's record. It is not appropriate to use the DF either casually or routinely to extend a course beyond the end of the semester or to extend a course for a student who has failed so that the individual can do extra work to improve the grade. ***The DF must be removed (i.e., the course must be completed) no later than 25 weeks after the course end date or it will be automatically changed to an F if the 25 weeks are exceeded.*** Instructors are not required to allow the full 25 weeks to elapse.

No deferred or missing grade may remain on the record once a student has completed a M.S. program and the doctoral qualifying, comprehensive, and final oral examinations. Graduate programs may add additional benchmarks.

1.6 - SARI

As part of the AMERICA Competes Act of 2007, the Federal Government is now requiring all graduate students to receive training in the responsible conduct of research.

During their first semester all new incoming COE graduate students will be required to complete the following:

SARI (Scholarship and Research Integrity) Requirements

The SARI program has two main components:

1. **Online Training:** You need to complete an online course on Responsible Conduct of Research (RCR) provided by CITI (Collaborative Institutional Training Initiative). Once completed, a printable certificate will be available that must be shown to the ESM Graduate Programs Assistant to verify completion.

and

2. **Discussion-based Education (total at least 5 hours):** You need to take part in a minimum of 5 hours of in-person, discussion-based educational activities that address topics related to the Responsible Conduct of Research (RCR) before graduation. This is a one-time requirement that does not need to be fulfilled each year.

   In our department you can fulfil this requirement by participating in ethics seminars and discussions which are part of EMCH/ESC 514 or ESC 515 courses.

   Fulfilling your SARI requirement at PSU is the responsibility of each graduate student and failing to do so will prevent you from being able to graduate on time.

   For schedule your online training and more information, please check:
   https://www.research.psu.edu/training/sari

It is important to note that your involvement in this program will give you important and marketable skills that employers will seek. Hence, in addition to learning valuable coursework and skill sets related to research and its ethical conduct, you will be learning professional skills highly sought by employers in industry, government, and academia.

1.7 - Policy SY01: Environmental Health and Safety Policy

PURPOSE:

The Pennsylvania State University is committed to protecting the health and safety of its employees, students, visitors and the environment. The purpose of this document is to establish an organizational structure to ensure the effective implementation of this policy at all University locations.

POLICY:

All employees, students and visitors are expected to comply with the statements that follow. Each department or unit shall supplement this policy document with specific procedures about hazards in their workplace and the precautions necessary to control and prevent these hazards. These

supplements, prepared in cooperation with the Office of Environmental Health and Safety, may be in the form of written procedures and/or training programs.

The responsibility for the administration of the University's health and safety program is assigned to the Office of Environmental Health and Safety. Implementation of this policy is the responsibility of the entire University community - staff, faculty and students.

The University Safety Council, with members representing the University's academic colleges and administrative units, is responsible to identify needs, develop procedures, and assist in the implementation of environmental health and safety programs under the direction of the Office of Environmental Health and Safety.

Applicable federal and state laws and regulations, together with policies and procedures issued by or through the office of Environmental Health and Safety, will provide the guidance under which the University will conduct its safety program.

Employees and Students:

1. All University employees and students have specific responsibilities to comply with established health and safety policies, standards, rules, procedures and regulations. Compliance with these is essential to create and maintain a healthy and safe environment at all University locations.

2. All persons working in a laboratory MUST complete the Environmental Health and Safety (EHS) Laboratory Safety Training. This training is found at
   www.ehs.psu.edu;
   Training Courses and Registration;
   EHS On-line Course Registration;
   Laboratory Safety

3. Comply with applicable environmental health and safety policies, standards, rules, regulations and procedures. These include safety-related signs, posters, warnings and written/oral directions when performing tasks.

4. Do not perform any function or operation which is considered hazardous or is known to be hazardous without proper instructions and authorization.

5. Only use equipment and materials approved or provided by the supervisor or instructor and for which instruction has been provided by this or other experience.

6. Become thoroughly knowledgeable about potential hazards associated with the work area; knowing where information on these hazards is maintained and how to use this information when needed.

7. Wear or use prescribed protective equipment.

Report all unsafe conditions, practices, or equipment to the supervisor, instructor or safety officer whenever deficiencies are observed.

Inform the supervisor or instructor immediately of all work-related injuries or accidents and obtain prompt medical attention when necessary.

8. Provide information necessary for the supervisor or safety officer to adequately and thoroughly complete the *Employer's Report of Occupational Injury and Illness* and any other associated accident/illness reports.

Chapter 2: Master's Degree in Engineering Science and Mechanics

The Department of Engineering Science and Mechanics offers a number of degree programs including: Master of Science of Engineering Science and Mechanics (MS ESMCH) thesis track, Master of Science of Engineering Science and Mechanics (MS ESMCH) non-thesis track, Master of Engineering in Mechanics (ME EMCH) and Master of Science in Engineering at the Nano-scale. The Integrated Undergraduate Graduate (IUG) program has the same requirements as the Master of Science of Engineering Science and Mechanics (MS ESMCH) thesis track.

A student beginning graduate work should immediately seek a research adviser and quickly begin the research that is required for the degree. Until a research adviser is found, the graduate officer will assist the student in selecting courses, planning a preliminary program of study, and answering any questions about the ESM Department, Graduate Program, and Graduate School. The candidate should feel free to approach any faculty member for advice and counsel, as well as to discuss potential research projects for their thesis. **This process should start on Day One** and continue in earnest until an adviser is found, otherwise, there may be significant delays in the research, graduation, and/or possible loss of financial support.

2.1 - Overview of Master of Science Degree (MS ESMCH)

A comparison of the thesis and non-thesis MS ESMCH tracks is shown in Table 2.1. The Master of Science Degree (M.S.) in Engineering Science and Mechanics thesis track requires a total of 32 credits, including 2 credits of seminar and 6 credits of thesis research, culminating in a written thesis with oral defense. This track typically requires at least four semesters to complete. The non-thesis track is aimed at preparing tomorrow's engineers in a very broad sense and is structured so that resident, full-time, students can complete the degree in 12 months. The non-thesis track requires a minimum of 32 course credits, including two seminar credits and 3 credits of a residential research experience and a scholarly paper. This interdisciplinary program is ideal for individuals with a bachelor's degree in physics, engineering, mathematics, or related fields who wish to gain a deeper knowledge of engineering science and mechanics fundamentals and applications and to explore research opportunities.

2.1.1 - MS ESMCH Thesis Track

The thesis track Master of Science Degree in Engineering Science and Mechanics requires a total of 32 credits, including 2 credits of seminar and 6 credits of thesis research, culminating in a written thesis with oral defense. This track typically requires at two years to complete.

The thesis required for the Master of Science degree in Engineering Science and Mechanics must be a well-organized account of research on an appropriate topic. In this research, the student must show initiative and originality and not merely carry out a routine test or investigation. The thesis must contain a nontechnical abstract as the last appendix to explain the contributions reported in the thesis in terms that members of the general public may understand.

The M.S. thesis will be examined by a master's committee consisting of three faculty members,

including the thesis adviser, and approved only after a satisfactory oral examination. ***It is the responsibility of the student to arrange the time and date of the examination and notify Ashley Cecil so it can be entered into LionPath milestones. The student has to deliver a draft of his or her thesis to each member of the committee at least two (2) weeks prior to the thesis defense date.*** The thesis adviser has to complete the Communications Rubric for Masters Degrees and return the completed document to Ashley Cecil.

A master's candidate is not required to register for the final semester in order to graduate or to make minor revisions to the thesis and/or take a final examination for the degree.

A completed and signed thesis (electronic uploaded) must be submitted to the Graduate School by the deadline set by the Graduate School. Prior to commencement, the student must deliver two copies of their thesis, bound in accordance with the Graduate School requirements, to the ESM department office.

The thesis defense is an important part of the degree and is open to the public. While each examination is related primarily to the thesis, the student can be asked other related/relevant questions. Moreover, the thesis presentation should emulate the presentation of a paper at a technical session of a national professional meeting. Specifically, the thesis defense should follow the 5 basic guidelines provided below:

1. It should be presented within a definite time period—approximately 20 – 30 minutes for an M.S.
2. The talk should be rehearsed with the actual visual aids prior to the presentation in order to comply with the time limitations.
3. As it is unlikely that a visual aid can be covered in less than one (1) to one and one-half (1½) minutes, a maximum of 20 – 25 visual aids is recommended.
4. The presentation should proceed without interruption from the audience.
5. Questions to the examinee must be answered by the examinee (i.e. not the thesis adviser).

It is important to note that an excessively long presentation may be rejected by the committee. Examinees should address the novel and challenging aspects of their research contributions. The thesis must contain a nontechnical abstract in addition to a technical abstract.

The unbound thesis must be submitted electronically via ETDs http://www.etd.psu.edu/ to the Graduate School by the deadline set by the Graduate School. Prior to commencement, the student shall deliver to the department office two acceptable copies of their thesis (one copy for the department file and the other for the adviser), bound in accordance with the requirements detailed in the Graduate School's Thesis Guide. The Thesis Guide is available on the Graduate School web site at:
http://www.gradsch.psu.edu/current/thesis.html.

Costs incurred for thesis binding are the responsibility of the student.

The M.S. thesis track requires 32 total credits, of which 24 are 3-credit 400/500 level classes in engineering/math/science, 6 are research credits (600 level), and 2 are seminar (EMCH/ESC 514).

Of the 24 course credits, 12 must be from the ESM department and have an E MCH or E SC prefix;

dual listed courses will count as long as one of the listings is from ESM. A maximum of 6 credits at the 400 level are allowed; any increase beyond the six (6) 400-level credits must be approved by the ESM Graduate Officer via a petition. Seminar credits cannot be used to satisfy general course requirements.

2.1.2 - MS ESMCH Non-Thesis Track

The M.S. non-thesis track also requires a minimum of 32 course credits, including two seminar credits and 3 credits of a residential research experience and a scholarly paper. The focus of the degree is on full-time resident students. It is expected to appeal to engineers and scientists interested in a variety of fields such as, but not limited to aerospace, agricultural and biological, architectural, biomedical, civil, mechanical, nuclear, and petrochemical engineering, engineering mechanics, engineering science, materials science, physics, chemistry, biology and medicine.

Before starting or during the first week of the fall semester, non-thesis M.S. students should investigate faculty research activities within the ESM department and contact faculty they are interested in working with so selection and discussion of the student's research project can begin as soon as possible. The scholarly paper must demonstrate the student's capability to integrate and apply concepts and techniques learned in the courses and thereby demonstrate the scientific, technical and ethical knowledge needed to practice engineering.

An electronic copy of the approved culminating research paper must be submitted to the ESM department at least two weeks before the end of semester classes. Students who need more time to complete the final paper may extend the submission due date after the third semester (summer). The degree will be granted after the paper has been reviewed and approved by their thesis adviser and Graduate Officer, and all degree requirements have been met. Students are not required to remain in residence while they complete the final paper. However, extensions granted to students in this program must comply with the Graduate Council policy on deferred grades. Subject to permission of the author, this paper will be posted on the department web site and will be available to interested persons.

2.2 - MS ESMCH Course Requirements for Thesis and Non-Thesis Tracks

Specific course requirements (see also Table 2.1) for thesis and non-thesis tracks in the Master of Science degree in Engineering Science and Mechanics (MS ESMCH) are listed below; ***It is the responsibility of the student and their adviser to make sure all of these requirements are met.***

1. E MCH 524A is required; if a student took 404H as an E SC undergraduate, then another high-level math such as E MCH 524B may be substituted.

2. At least one course from each of the categories Mechanics, Materials, and Engineering Science must be taken as summarized in Table 2-2. ***Failure to take courses from these categories may require additional coursework and delays in graduation. It is the responsibility of the student and their adviser to make sure these requirements are met.***

3. 2 seminars (E MCH/E SC 514)

4. 6 Thesis Research (600 level) credits are required for the Thesis Track. 3 Independent Study (ESC or E MCH 596) credits are required for the Non-Thesis Track

5. The remaining course credit requirements may be taken at the discretion of the student and their academic/thesis adviser provided they satisfy the requirements of Table 2-1.

6. Please note that the categories Engineering Science, Mechanics, and Materials were selected to give the students breadth and depth and encompass both 400 and 500 level courses.

Table 2-1: Degree Requirements

	M.S. thesis Track	M.S. Non-Thesis Track
Total number of course credits	24	27
Recommended number of semesters	4 (2 fall and 2 spring)	3 (fall, spring, summer)
Minimum number of E SC/E MCH credits	12 Including E MCH 524A	15 Including E MCH 524A
Maximum number of credits at 400 level	6	6
Core courses required	One mathematics course plus one from each category: materials, mechanics, engineering science (see Table 2.2) 12 credits	One mathematics course plus one from each category: materials, mechanics, engineering science (see Table 2.2) 12 credits
Graduate seminar (E SC/E MCH 514)	2	2
Research credits towards M.S. degree	E SC/E MCH 600 6 credits[1]	E SC/E MCH 596 3 credits
Culminating experience	Completion of research thesis and oral defense	Completion of a written scholarly paper and presentation
Total credits	32	32

[1] M.S. students are allowed a maximum of 6 credits of letter grades for 600 level courses.

In order to provide a wide selection, many courses are from outside the ESM Department and some are listed in more than one category.

Core Course E MCH 524A: All M.S. students are required to take a graduate level applied mathematics course. If a student has taken E SC 404H, then another high-level mathematics course such as E MCH 524B may be substituted.

At least one course from each of the categories A) Mechanics, B) Materials, and C) Engineering Science must be taken as summarized in Table 2-2.

The remaining course credit requirements may be taken at the discretion of the student and their research adviser provided they satisfy the requirements of Table 2-2.

Table 2-2: Course Designations for Mechanics/Materials/Engineering Science

Mechanics: Select at least one course from the following list		
Mechanics is interpreted in its broadest context to include biomechanics, celestial mechanics, computational mechanics, fluid mechanics, quantum mechanics, solid mechanics, statistical mechanics, structural mechanics, and wave mechanics, among others).		
E MCH	400	Advanced Strength of Materials and Design
E MCH	402	Applied and Experimental Stress Analysis
E MCH	403	Strength Design in Materials and Structures
E MCH	407	Computer Methods in Engineering Design
E MCH	409	Advanced Mechanics
E MCH	416H	Failure and Failure Analysis of Solids
E MCH MATSE	440 440	Nondestructive Evaluation of Flaws
E MCH	446	Mechanics of Viscoelastic Materials
E MCH	461	Finite Elements in Engineering
E MCH	470	Analysis and Design in Vibration Engineering
E MCH	471	Engineering Composite Materials
E MCH AERSP	473 473	Composites Processing
E MCH	500	Solid Mechanics
E MCH	506	Experimental Stress Analysis3.0
E MCH	507	Elasticity
E MCH	516	Mathematical Theory of Elasticity
E MCH	520	Advanced Dynamics
E MCH	521	Stress Waves in Solids
E MCH	523	Ultrasonic Nondestructive Evaluation
E MCH	524B	Mathematical Methods in Engineering
E MCH	524C	Mathematical Methods in Engineering
E MCH	530	Mechanical Behavior of Materials
E MCH	532	Fracture Mechanics
E MCH	533	Scanned Image Microscopy
E MCH	534	Micromechanics of Fracture
E MCH	535	Deformation Mechanisms in Materials
E MCH	536	Thermal Stress Analysis
E MCH	540	Introduction to Continuum Mechanics
E MCH	541	Structural Health Monitoring
E MCH	542	Physical Principles in Biomedical Ultrasonics
E MCH	544	Multiscale Modeling of Materials
E MCH	560	Finite Element Analysis

E MCH AERSP M E	571 571 571	Foundation of Structural Dynamics and Vibration
E MCH	581	Micromechanics of Composites
E MCH	582	Metal Matrix Composites
E SC	481	Elements of Nano/Micro-Electromechanical Systems Processing and Design
E SC	482	Micro-Optoelectromechanical Systems (MOEMS) and Nanophotonics
E SC	536	Wave Propagation and Scattering
E SC	583	Micro and Nano Optoelectronic Devices and Application
BIOE	505	Bioengineering Mechanics
BIOE	510	Biomedical Applications of Microelectromechanical Systems (BioMEMS) and Bionanotechnology
BIOE	515	Cell Mechanics and Biophysics
BIOE I E	552 552	Mechanics of the Musculoskeletal System
BIOE I E	553 553	Engineering of Human Work
PHYS	410	Introduction Quantum Mechanics I
M E	555	Automatic Control Systems
M E	564	Elastic and Dynamic Stability of Structures
M E	580	Advanced Dynamics of Machines
M E	582	Mechanism Synthesis
AERSP	506	Rotorcraft Dynamics
AERSP	508	Foundations of Fluid Mechanics
AERSP	518	Dynamics and Control of Aerospace Vehicles
AERSP	550	Astrodynamics
CHEM	565	Quantum Chemistry I

Materials: Select at least one course from the following list; each is a 3-credit course.

E MCH	402	Applied and Experimental Stress Analysis
E MCH	416H	Failure and Failure Analysis of Solids
E MCH	440	Nondestructive Evaluation and Flaws
E MCH	446	Mechanics of Viscoelastic Materials
E MCH	471	Engineering Composite Materials
E MCH AERSP	473 473	Composites Processing
E MCH	506	Experimental Stress Analysis
E MCH	530	Mechanical Behavior of Materials
E MCH	534	Micromechanics of Fracture
E MCH	535	Deformation Mechanisms in Materials
E MCH	544	Multiscale Modeling of Materials
E MCH	582	Metal Matrix Composites
E SC	414M	Elements of Material Engineering
E SC	419	Electronic Properties and Applications of Materials

E SC	445	Semiconductor Optoelectronic Devices
E SC	450	Synthesis and Processing of Electronic and Photonic Materials
E SC	455	Electrochemical Methods in Corrosion Science and Engineering
E SC	475	Particulate Materials Processing
E SC	482	
E SC	483	Simulation and Design of Nanostructures
E SC	484	Biologically Inspired Nanomaterials
E SC	501	Solar Cell Devices
E SC	502	Semiconductor Heterojunctions and Applications
E SC	503	Low Dimensional Nanoelectronics
E SC	511	Engineering Materials for Energy Conversion and Storage
E SC	518	Bioprinting
E SC	536	Wave Propagation and Scattering
E SC	537	Multiple Scattering Theories and Dynamic Properties of Composite Materials
E SC	543	Laser Micro processing
E SC	545	Scientific and Engineering Foundations of Additive Manufacturing
E SC	550	Power Semiconductor Devices
E SC	551	High Power Energy Storage
E SC	555	Neuroscience Data Analysis
E SC	582	Micro- and Nano-Structured Light Emitting Devices
E SC	583	Micro-and Nano Optoelectronic Devices and Applications
E SC	584	Introduction to Bio-Architecture
BIOE	512	Cell and Molecular Bioengineering
BIOE	517	Biomaterials Surface Science
CHEM	448	Surface Chemistry
CHEM	543	Polymer Chemistry
MATSE	400	Crystal Chemistry
MATSE	413	Solid-State Materials
MATSE	414	Mechanical Properties of Ceramics
MATSE	436	Mechanical Properties of Materials
MATSE	504	Solid State Materials
MATSE BIOE	507 517	Biomaterials Surface Science
Materials Cont'd: Select at least one course from the following list; each is a 3-credit course.		
MATSE BIOE	508 508	Biomedical Materials
MATSE	512	Crystal Chemistry

MATSE	514	Characterization of Materials
MATSE	544	Computational Materials Science of Soft Materials
MATSE	545	Mechanical Properties of Ceramics 1
MATSE	564	Deformation Mechanisms in Materials
MATSE	581	Computational Materials Science II: Continuum, Mesoscale Simulations
MATSE	501	Thermodynamics of Materials
MATSE	503	Kinetics of Materials Processes
MATSE	512	Principles of Crystal Chemistry
Engineering Science: Select at least one course from the following list; each is a 3-credit course.		
E MCH	407	Computer Methods in Engineering Design
E MCH	461	Finite Elements in Engineering
E MCH	533	Scanned Image Microscopy
E MCH BIOE I E	552 552 552	Mechanics of the Musculoskeletal System
E MCH	560	Finite Element Analysis
E MCH M E	563 563	Nonlinear Finite Elements
E SC	400H	Electromagnetic Fields
E SC	407H	Computer Methods in Engineering Science, Honors
E SC	445	Semiconductor Optoelectronic Devices
E SC E E EGEE	456 456 456	Introduction to Neural Networks
E SC	475	Particulate Materials Processing
E SC	481	Elements of Nano/Micro-electromechanical Systems Processing and Design
E SC	482	Micro-Optoelectromechanical Systems (MOEMS) and Nanophotonics
E SC	483	Simulation and Design of Nanostructures
E SC	484	Biologically Inspired Nanomaterials
E SC	501	Solid State Energy Conversion
E SC	502	Semiconductor Heterojunctions and Applications
E SC	505	Wearable Electronics
E SC	520	Engineering at the Nanoscale
E SC	521	Pattern Transfer at the Nanoscale
E SC	522	Fabrication and Characterization for Top-Down Manufacturing
E SC	523	Fabrication and Characterization for Bottom-up Nano-manufacturing

E SC	525	Neural Engineering: Fundamentals of Interfacing with the Brain
E SC	527	Brain Computer Interfaces
E SC	536	Wave Propagation and Scattering
E SC	540	Laser Optics Fundamentals
E SC	541	Laser-Materials Interactions
E SC	542	Laser-Integrated Manufacturing
E SC	544	Laser Laboratory
E SC	550	Power Semiconductor Devices
E SC	551	High Power Energy Storage
E SC	577	Engineered Thin Films
E SC	581	Microelectromechanical Systems/Smart Structures
CHEM	466	Molecular Thermodynamics
E E	420	Electro-Optics: Principles and Devices
E E	422	Optical Engineering Laboratory
E E	432	RF and Microwave Engineering
E E	442	Solid State Devices
E E	522	Electro-Optics Laboratory
E E	542	Semiconductor Devices
PHYS	524	Physics of Semiconductors and Devices
PHYS	572	Laser Physics and Quantum Optics

SEMINAR: Select two seminars from the following list; each is a 1-credit course.

E MCH	514 (1 cr.)	Engineering Science & Mechanics Seminar
E SC	514 (1 cr.)	Engineering Science & Mechanics Seminar

THESIS RESEARCH: Select 6 credits from the following list; each is a variable credit course offering.

E MCH	600	Thesis Research
E MCH	610	Thesis Research Off Campus
E SC	600	Thesis Research
E SC	610	Thesis Research Off Campus

2.3 - Non-Thesis Master of Science Degree: Engineering at the Nanoscale

Practicing engineering at the nanoscale is an undertaking that builds on a foundation of engineering at the micro-scale and requires a broad background encompassing advanced safety and environmental impact knowledge, ethics awareness, broad technical depth, and interdisciplinary professional preparation. The requirements for one-year M.S. in Engineering at the Nanoscale are presented in Table 2-3.

Table 2-3: Degree Requirements for One-Year Residence-Based M.S. Degree in Engineering at Nanoscale

Total number of course credits	27
Minimum number of course credits from the ESM department	15 (5 core courses)
Minimum number of 500 level course credits	21 out of 30
Colloquium credits	None
Research credits	3 (E SC 596)
Total number of credits	30

Students seeking the one-year residence-based Master of Science (M.S.) degree in Engineering at the Nanoscale will be required to start their degree in fall semester of every year and complete all the required course work and their degree by the end of the following summer.

The proposed plan of study (Table 2-4) is as follows:

- Fall semester: 12 credits of course work + 1 credit of E SC 596 Individual Study
- Spring semester: 12 credits of course work + 1 credit of E SC 596 Individual Study
- Summer semester: 3 credits of course work + 1 credit of E SC 596 Individual Study

This one-year residence-based Master of Science (M.S.) degree in Engineering at the Nanoscale culminates with 3 credits of research (E SC 596) which must result in a scholarly paper that satisfies the Graduate School requirement for a culminating research experience. This culminating experience may include students making use of the facilities of the ESM Teaching/Videoing Nanotechnology cleanroom of the ESM Center for Nanotechnology Education and Utilization (CNEU) in their research.

NOTE: To fulfill SARI requirements students need to complete 2 components (as indicated in Chapter 1.6): online training and discussion – based education. An online course on Responsible Conduct of Research is provided by CITI (Collaborative Institutional Training Initiative) and 5 hours of responsible conduct of research (RCR) will be addressed through five hours of both lectures/discussions and assignments in ESC520 in a special section of the course discussing the societal and economic impact of nanotechnology. Participation in a part of E MCH/E SC 514 seminar or ESC 515 course covering these issues is also encouraged.

It is the responsibility of the student and his/her adviser to make sure these requirements are met.

The topic of the scholarly paper will be determined by the M.S. Nano Program Director and the student. The scholarly paper must demonstrate the student's capability to integrate and apply concepts and techniques learned in the courses and thereby demonstrate the technical, environmental, ethical, and safety knowledge needed to practice engineering at the nanoscale. **An electronic copy of the**

approved culminating research paper must be submitted to the ESM department at least two weeks before the end of summer classes. Students who need more time to complete the final paper may extend the submission due date after the third semester (summer). The degree will be granted after the paper has been reviewed and approved, and all degree requirements have been met. Students are not required to remain in residence while they complete the final paper. Subject to permission of the author, this paper will be posted on the department web site and will be available to interested persons.

Core Courses: The Engineering at the Nanoscale graduate program requires 5 core courses (15 credits) in addition to the 3 credits of E SC 596 research experience for this one-year residence-based Master of Science (M.S.) degree. A suggested plan of study is presented in Table 2-4. The core courses are as follows:

- E SC 412 Nanotechnology: Materials, Infrastructure, and Safety
- E SC 520 Engineering at the Nanoscale
- E SC 521 Pattern Transfer at the Nanoscale
- E SC 522 Fabrication and Characterization for Top-down Nano-manufacturing
- E SC 523 Fabrication and Characterization for Bottom-up Nano-manufacturing

Table 2-4: Plan of Study

Fall Semester (13 credits)	
E SC 412	**Core 1 (3)**
E SC 520	**Core 2 (3)**
E SC 521	**Core 3 (3)**
ELECTIVE	**SELECT Elective (3)**
E SC 596	**Individual Study (1)**
Spring Semester (13 credits)	
E SC 522	**Core 4 (3)**
E SC 523	**Core 5 (3)**
ELECTIVES	**SELECT Electives (6)**
E SC 596	**Individual Study (1)**
Summer Semester (4 credit)	
E SC 596	**Individual Study (1)**
ELECTIVE	**SELECT Elective (3)**
SARI requirements (5 hours) must be fulfilled in E SC 596.	

Elective Courses:

Four 3-credit electives in the program may be selected from any of the courses listed below. These courses can be arranged into three emphasis areas, Energy, Electronics and Photonics, and Materials (examples are listed in Table 2.5). It must be stressed that these tables are examples only. Students do not have to take these specific electives but may choose 4 different elective courses subject to the requirement that at least 2 courses must be 500-level courses and approved by the M.S. Nano Director.

- E SC 414M Elements of Material Engineering
- E SC 445 Semiconductor Optoelectronic Devices
- E SC 450 (MATSE 450) Synthesis and Processing of Electronic and Photonic Materials
- E SC 481 Elements of Nano/Micro-electromechanical Systems Processing and Design
- E SC 482 Micro-optoelectromechanical Systems (MOEMS) and Nanophotonics
- E SC 483 Simulation and Design of Nanostructures
- E SC 484 Biologically Inspired Nanomaterials
- BIOE 512 Cell and Molecular Bioengineering
- CHEM 511 Chemical Nanoscience
- E SC 501 Solar Cell Devices
- E SC 502 Semiconductor Heterojunctions and Applications
- E SC 511 Engineering Materials for Energy Conversion and Storage
- E SC 541 Laser-Materials Interactions
- E SC 542 Laser-Integrated Manufacturing
- E SC 550 Power Semiconductor Devices
- E SC 551 High-Power Energy Storage
- E SC 577 Engineered Thin Films
- E SC 581 Microelectromechanical Systems/Smart Structures
- E SC 582 Micro- and Nano-Structured Light Emitting Devices
- E SC 583 Micro- and Nano-Optoelectronic Devices and Applications
- E SC 584 Introduction to Bio-Architecture
- E MCH 597 (E MCH 543) Shape Memory, Smart Materials and Mechanical Behavior
- E MCH 544 Multiscale Modeling and Materials
- E MCH 597 (E MCH 545) Nanomechanics

Research Experience:

- *E SC 596 Individual Study*

Important: The 596 Graduate Individual Studies form must be obtained from the graduate programs assistant, completed by student and faculty, signed and then returned to the graduate programs assistant for the course to be entered in LionPATH

Table 2-5: Three Emphasis Areas

Energy Emphasis	Electronics and Photonics Emphasis	Materials Emphasis
E SC 450 (MATSE 450) Synthesis and Processing of Electronic and Photonic Materials	E SC 445 Semiconductor Optoelectronic Devices	E SC 414M Elements of Material Engineering
E SC 501 Solar Cell Devices	E SC 450 (MATSE 450) Synthesis and Processing of Electronic and Photonic Materials	E SC 450 (MATSE 450) Synthesis and Processing of Electronic and Photonic Materials
E SC 502 Semiconductor Heterojunctions and Applications	E SC 482 Micro-Optoelectromechanical Systems (MOEMS) and Nanophotonics	E SC 481 Elements of Nano/Micro-electromechanical Systems Processing and Design
E SC 511 Engineering Materials for Energy Conversion and Storage	E SC 501 Solar Cell Devices	E SC 483 Simulation and Design of Nanostructures
E SC 551 (M E 551) High Power Energy Storage	E SC 502 Semiconductor Heterojunctions and Applications	E SC 541 Laser-Materials Interactions
E MCH 597 (E MCH 545) Nanomechanics	E SC 582 Micro- and Nano-Structured Light Emitting Devices	E SC 542 Laser-Integrated Manufacturing
CHEM 511 Chemical Nanoscience	E SC 583 Micro- and Nano-Optoelectronic Devices and Applications	E MCH 544 Multiscale Modeling and Materials
		E MCH 597 (E MCH 545) Nanomechanics
		Chem 511 Chemical Nanoscience

Important note: International students entering nano program are required to take AEOCPT test the first semester they are in residence. https://aplng.la.psu.edu/programs/about-the-aeocpt

2.4 - Master of Engineering in Engineering Mechanics

Before starting or during the first week of the fall semester, students should investigate faculty research activities within the ESM department and contact faculty they are interested in working with so selection and discussion of the student's research project can begin as soon as possible. The scholarly paper must demonstrate the student's capability to integrate and apply concepts and

techniques learned in the courses and thereby demonstrate the scientific, technical and ethical knowledge needed to practice engineering.

While this degree is based primarily on graduate lecture course work, the candidate is required to submit to the department a scholarly written report on a developmental study involving at least one area represented in the course work. A maximum of three credits of E MCH/E SC 596 can be assigned to the work performed on the M. Eng. report. The report must be comparable in its level of work and quality to a graduate thesis. Furthermore, it must also contain a nontechnical abstract in addition to the usual technical abstract.

At least **two weeks prior to commencement**, the graduate student shall deliver to the department office, two acceptable bound copies of his or her paper for retention by the department. In addition, an oral examination based on the student's study and course work will be administered to the candidate. Residence at University Park Campus is not required (provided the department or supervisory committee and the dean of the Graduate School agree that a complete program of study can be pursued at, for example, Penn State Harrisburg, Penn State Erie, or Penn State Great Valley).

The course requirements for the Master in Engineering in Engineering Mechanics are as follows: 31 total credits, of which 27 are 3-credit 400/500 levels classes in engineering/math/science, 3 course credits can be independent study towards the project report (E MCH/E SC 496/596), and 1 seminar (E MCH/E SC 514). Of the 27 course credits, 21 must be from this department and have an E MCH or E SC prefix; dual listed courses will count as long as one of the listings is from ESM. A maximum of 6 credits at the 400 level are allowed for the coursework; any increase beyond the six 400-level credits must be approved by the ESM graduate officer via a petition. The seminar credit cannot be used to satisfy general course requirements. A summary of the general course requirements for the M. ENG degree is shown below in Table 2-6.

Table 2-6: Courses Credit Overview for M ENG Degree

1.	Total (all courses including required)	31
2.	Analysis	3 (min)
3.	Fields	3 (min)
4.	Motion	3 (min)
5.	Materials	3 (min)
6.	E MCH/E SC 514 (Seminar)	1
7.	Independent Study (E MCH/E SC 496/596)	3 (max)

Specific course requirements for the Master of Engineering in Engineering Mechanics (M ENG) are straightforward and go as follows: Beyond the 1 credit in seminar (E MCH/E SC 514), no specific courses are required. However, students are required to take at least one (1), 400/500 level course from four specific categories designated as: Analysis, Fields, Motion, and Materials. The remaining course credit requirements may be taken at the discretion of the student and their academic/report adviser provided they satisfy the requirements of Table 2-6. Table 2-7 shows the overall course and

credit structure of the M ENG degree while Table 2-8 lists the courses corresponding to Analysis, Fields, Motion, and Materials. Additional courses belonging to these categories may be approved by the ESM graduate officer via a petition. Please note that the categories were selected to give students breadth and depth in the core aspects of Engineering Mechanics and encompass both 400 and 500 level courses.

Table 2-7: Required Courses Overview for M ENG Degree

1.	Total	31
2.	At University Park Campus	24
3.	400 courses	0 - 6
4.	500 courses	27 - 22
5.	E MCH and/or E SC (except 514 or 600)	22
6.	E MCH/E SC 514 (Seminar)	1
7.	Independent Study (E MCH 496 or 596)	3

Table 2-8: Required Course Categories for M ENG Degree

Analysis	Fields	Motion	Materials	
E MCH/E SC 407	E MCH 400/500	E MCH 401	E MCH 402/506	E SC 502
E MCH 461/560	E MCH 507	E MCH 409/520	E MCH 403	E SC 540
E MCH 524A	E MCH 446/546	E MCH 412/528	E MCH 440	E SC 541
E MCH 524B	E MCH 509	E MCH 470	E MCH 530	E SC 543
E MCH 550	E MCH 516	E MCH 523	E MCH 532	E SC 544
E MCH 562	E MCH 521	E MCH 525	E SC 501	E SC 577
E MCH 563	E MCH 531	E MCH 527	E MCH 471	E MCH 544
E SC 404H	E MCH 540	E MCH 570	E MCH 473	
E SC 406H	E MCH 581	E MCH 571	E MCH 534	
E SC 456	E SC 400H	E SC 551	E MCH 535	
E MCH 544	E SC 405		E MCH 582	
	E SC 445		E SC 414M	
	E SC 536		E SC 450	
	E SC 537		E SC 455	
	E SC 540		E SC 475	
			E SC 481/581	

NOTE: Students are required to devote at least 5 hours to learn about responsible conduct of research (RCR) covering publication practices and responsible authorship, conflicts of interest, research misconduct, ethics, peer review, mentoring, data management, and collaborative research as specified by the Graduate School for Scholarship and Research Integrity (SARI)

requirements. The best approach would be to participate in a part of E MCH/E SC 514 seminar covering these issues, in addition to the E MCH/E SC 514 seminar taken for 1 credit (= seminar taken in full for one semester and seminar's SARI part only in the following semester)

Important: All Masters students (thesis and non-thesis options) and Nano and MEng MS need to have completed Written Communication Rubric submitted to Graduate Officer. The rubric is shown in Appendix A

2.5 - Time Limits for All Masters' Degrees

All requirements for a master's degree comprising the M.S. and M.ENG. (including acceptance of a thesis, paper, or project report as may be specified), whether satisfied on the University Park campus or elsewhere, must be met within 8 years of admission to degree status. Extensions may be granted by the Graduate School in appropriate circumstances.

2.6 - Integrated Undergraduate/Graduate Study (IUG)

Integrated Undergraduate/Graduate Study (IUG) status permits students to take on the rigors and research challenges of graduate study at Penn State while coordinating and combining them with their baccalaureate studies and senior thesis. Since up to 12 credits earned as an undergraduate may be applied to both degree programs, and the M.S. thesis is an expansion of the B.S. thesis, the time required for completion of integrated undergraduate/graduate studies is normally less than for the separate degree programs. Students interested in the IUG program should refer to section 2.1.1 to become familiar with the course and research credit requirements. Actual time is determined by the individual student's objectives, needs, and diligence. In no case, however, should the acceleration of work in the major be at the expense of the richest possible undergraduate and graduate experience. Hence, there must be a balance between the accelerated specialization and a sound general education. More information on the IUG program may be found at http://www.gradschool.psu.edu/faculty-and-staff/faculty/iugs/.

2.6.1 - IUG Application Procedures and Guidelines

1. IUG proposals may be initiated by Engineering Science students with a **GPA of 3.4 or better**. Time of admission to the program: Students **shall be admitted** to an IUG program no earlier than the beginning of the third semester of undergraduate study at Penn State (regardless of transfer or AP credits accumulated prior to enrollment) and **no later than the end 6th semester of expected conferral of the undergraduate degree**, as specified in the proposed IUG plan of study. It is important to contact the ESM Graduate Officer to start the process.

   Example IUG Application Timeline assuming graduation in the 8th semester:

   During the 6th semester:
   - Student finds a research adviser and works with the adviser to develop the IUG research plan (see departmental website for faculty listing).
   - Schedule a meeting with the ESM Graduate Officer to confirm interest in the IUG program and to review the completed IUG supplemental application form.
   - Complete Application to the Graduate School and choose the 7th undergraduate semester as the semester for graduate admissions consideration. (to clarify: choose the

first semester of your senior standing). Notify the graduate officer (graduate school does not contact ESM after the application is complete)

- The ESM graduate admissions committee will review the application and notify the student.

2. The application for IUG status should include the following information.

    a) An explicit plan of study leading to the M.S. Degree is required. The IUG supplemental application form must be filled and it can be found at: https://sites.esm.psu.edu/wiki/_media/esm_iug_supplemental_application_form.pdf NOTE: As many as 12 of the credits required for the master's degree may be applied to both undergraduate and graduate degree programs. Any 400 or 500 level engineering, math and/or science courses ***not required or used as foundational elective*** for the ESC BS degree can be double counted. A minimum of 50 percent of the courses proposed to count for both degrees must be at the 500 level. Thesis credits may not be double counted.
    Important: EMCH/ESC 496/596 independent study courses cannot be used for double counting

    b) A financial plan. The applicant must discuss a financial plan with the prospective research mentor for the master's program must submit a financial plan for funding the applicant for the period between the conferral of the bachelor's and the master's degrees. The financial plan must address the payment of tuition and fees as well as a monthly stipend for living expenses and health insurance, in accordance with the prevailing rules of the Graduate School. Visit http://gradsch.psu.edu/current/funding.html for funding modes and http://tuition.psu.edu/CostEstimate.asp for estimated tuition and fees. The applicant may be self-funded or funded through external scholarships or through a research assistantship by the prospective research mentor. An applicant who is not offered a research assistantship, fellowship, or external scholarship will be eligible for a teaching assistantship from the ESM department, subject to availability of funds. ***When available, TA support for all IUG students is limited to a maximum of 2 semesters.*** The applicant must contact the graduate officer to discuss the financial plan after meeting with the research adviser to discuss funding options.

3. IUG applicants must complete and submit an application to the Penn State Graduate School (http://www.gradschool.psu.edu/apply/). The following documents should be generated before uploading them to the Graduate Admissions website.

    a) A personal statement that summarizes the student's academic progress, outlines long-term goals, states the proposed use of IUG status, and addresses in moderate detail the research area that will constitute the focus of the graduate degree. Usually, one page is sufficient.

    b) Three faculty recommendations including one from the academic adviser, as well as the prospective research mentor for the master's program if different. The latter must address the details of the proposed area of research focus and assess the student's ability to conclude the program. These recommendations will be uploaded to the

Graduate Admissions website by the faculty. Applicants will need to contact the faculty to ask for a recommendation and then supply their contact information on the Reference Section of the Graduate Admissions website.

c) Full transcript of undergraduate courses

d) GRE scores are not required for Penn State undergraduate students.

4. Applicants are notified by the action of the ESM Graduate Committee. When a candidate has been approved for IUG status by the Engineering Science and Mechanics Department, Schreyer Honors College (if appropriate) and the Graduate School, he or she will receive a letter of notification from the Graduate School Director of Graduate Admissions.

5. Undergraduate tuition rates will apply as long as the student is an undergraduate, unless the student receives financial support such as a research or teaching assistantship that covers the payment of graduate tuition.

6. Students must fulfill basic undergraduate requirements first so that if, for some reason, they cannot continue in the integrated program they will be able to receive their undergraduate degree without a significant loss of time**.**

7. 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.

8. A student may retain IUG status for as long as he or she maintains a GPA of 3.2 or better. If the GPA falls below 3.2, the ESM Undergraduate Officer and the ESM Graduate Officer shall jointly review the student's performance to ascertain if the student could be allowed a probationary period of a semester to meet or exceed the 3.20 GPA requirement in light of extenuating circumstances. If IUG status is terminated, the provisions of item 2(a), above, relative to 9 credits being applicable to both an undergraduate and graduate degree program, cease to apply. Termination of the IUG status would require the student to fulfill all regular requirements of the M.S. degree program in order to obtain the M.S. ESMCH degree

9. An appropriate notation of participation in the Integrated Undergraduate/Graduate Study (IUG) program will be made on the student's transcript.

A Schreyer Scholar who is granted Integrated Undergraduate-Graduate (IUG) status will have dual enrollment in an undergraduate program and in the Graduate School. Up to 12 graduate credits (400, 500 series) earned as an undergraduate may be applied to both degree programs. Guidelines and information are available from the Schreyer Honors College. It should be noted that while the Schreyer Honors College may only require a single thesis for the Schreyer IUG program, students in the ESM IUG program are required to submit both an undergraduate thesis for the B.S. Engineering Science Degree and a M.S. thesis for the M.S. ESMCH Degree.

NOTE: IUG students who wish to enroll into the Ph.D. program offered by the Department of Engineering Science and Mechanics at Penn State may do so only AFTER finishing the IUG

Program. Students must complete ALL requirements for the M.S. degree (including submitting and defending the Master's thesis) prior to starting their Ph.D. degree.

There are two forms concerning course selection:

- Supplemental form (available on ESM website) – must be submitted to Grad Officer and Grad Assistant when the IUG application is being initiated. It is essentially a plan of study for the whole IUG period. It should list courses a student, together with his adviser, select to be taken during IUG period. The undergraduate portion of it (senior year) will have double counted courses. This form will be submitted only once. Table 2-9 explains which courses can be listed on the form.
- Semester report (Table 2-10 – form on a Grad school website) - must be submitted every semester listing courses a student is actively enrolled in

Table 2-9: Explanation of courses to be listed in IUG supplemental form

IUG Supplemental Application Form for Engineering Science Majors

This form MUST be completed and submitted to Engineering Science and Mechanics Graduate Officer

Name _____ Expected Graduate Date _____

Are you a Schreyer Honors Scholar? ☐ **Yes** ☐ **No**

Double-Counted Undergraduate/Graduate Courses (12 Credits)

You need to be actively enrolled in the courses you are choosing for double counting

The following course(s) should be counted toward both the baccalaureate degree and the master's degree. A maximum of 12 credits may be double-counted throughout the duration of the program and half

Course abbreviation and number	Credits
ESC or EMCH 4xx	3
ESC or EMCH 4xx	3
ESC or EMCH 5xx	3
ESC or EMCH 5xx	3

Graduate Courses Only (12 Credits)

The following course(s) should be counted toward the **master's degree ONLY.** (NOTE: These courses cannot count toward honors credits.) These courses must be 500 level

A total of 24 credits is required for the M.S. degree.

Course abbreviation and number	Credits
ESC or EMCH 5xx	3
ESC or EMCH 524A	3
ESC or EMCH 5xx	3
ESC or EMCH 5xx	3

Since identification of double-counted UG courses could be confusing here are important points:

- **you cannot use FOUNDATIONAL ELECTIVES UNLESS they were NOT used to fulfill Engineering Science degree requirement**
- **you cannot use ANY REQUIRED COURSES -e.g. ESC 414, 404, 407, or 410.**
- **You cannot use any INDEPENDENT STUDY 496/596 courses**
- **You cannot use THESIS RESEARCH (600)/CAPSTONE EXPERIENCE**

Table 2-10: Example of IUG Semester report

Integrated Undergraduate/Graduate Semester Report

Office of Graduate Enrollment Services, The Pennsylvania State University, 114 Kern Building, University Park, PA 16802-3396; (814) 865-1795; (814) 863-4627(fax)

This form MUST be completed each semester and submitted to Graduate Enrollment Services for final approval once all the signatures have been obtained.

The course information listed below relates only to _____ / _____ .
Semester/Year

Last Name | First Name | Middle Initial | PSU ID

Undergraduate Degree | Undergraduate Major | Anticipated Semester/Year of graduation

Graduate Degree | Graduate Major | Anticipated Semester/Year of graduation

Are you a Schreyer Honors Scholar? ☐ **Yes** ☐ **No**

Double-Counted Undergraduate/Graduate Courses

The following course(s) should be counted toward both the baccalaureate degree and the master's degree. A maximum of 12 credits may be double-counted throughout the duration of the program and at least half of all shared courses must be at the 500/800 level.
Check with your program to determine how many credits you are permitted to double-count.

Course abbreviation and number	Credits

Graduate Courses Only

The following course(s) should be counted toward the master's degree ONLY. (NOTE: These courses cannot count toward honors credits.)

Course abbreviation and number	Credits

Signature of Student | Printed Name | Date

Signature of Graduate Program Head | Printed Name | Date

Signature of Undergraduate Program Adviser | Printed Name | Date

Signature of College Associate Dean for Undergraduate Education
(From the College of the student's undergraduate major) | Printed Name | Date

Signature of Graduate School/Graduate Enrollment Services | Printed Name | Date

CC: Schreyer Honors College
Registrar's Office
Graduate Program

PENNSTATE *The* GRADUATE SCHOOL

Chapter 3: Doctor of Philosophy in Engineering Science and Mechanics

The Ph.D. in Engineering Science and Mechanics (ESMCH) degree may be attained after completing the Engineering Science and Mechanics M.S. program (including IUG) or directly from a B.S. degree. For students holding a B.S. degree, the M.S. ESMCH guidelines already discussed (see section 2.1) must be followed along with the additional requirements outlined below.

The Ph.D. ESMCH degree is conferred in recognition of high attainment and productive scholarship. Admission to candidacy is by examination. Thereafter, the student's work is supervised by an *ad hoc* committee of the Graduate Faculty, which administers the examinations required by the department and Graduate School and reports the outcome to the Graduate School via the department. Certain departmental requirements must also be met.

While a student may be admitted to the Graduate School and the department to begin working towards a doctoral degree, the student is not a doctoral candidate until he or she has passed a qualifying examination and has been admitted to candidacy. Admission to candidacy will be based on:

1 The academic record of the student.
2 The opinion of the Graduate Faculty of the Department regarding his or her overall fitness for candidacy.
3 The results of a qualifying examination.

3.1 – The Qualifying Examination

All Ph.D. students must take a Qualifying Examination (QE) in compliance with the PSU Graduate School Qualifying Examination policy (GCAC-604). The ESM QE policy detailed here is consistent with GCAC-604 and adds program-specific considerations to it.

3.1.1 Premise

The following terms recur in this policy:

ESM Graduate Program Head: Policy GCAC-101 of the Penn State Graduate School defines the "Graduate Program Head" to be a member of the Graduate Faculty with ultimate responsibility and academic authority for a graduate degree program. For departmental graduate programs, this may be the Department Head. In the ESM Department, the Graduate Program Head is identified within the administrative leadership roster. The ESM Graduate Program Head is typically assisted by the ESM Graduate Director.

Adviser: The ESM graduate program requires each student to secure an adviser from the ESM graduate faculty ahead of the QE. A current list of all ESM graduate faculty is available in the departmental website. While not required, it is anticipated that the adviser of a student at the time of the student's QE will serve as the student's primary mentor in the program and

will serve as the chair of the student's dissertation committee. As a student can have more than one adviser, in this document the word "adviser" stands for the individual or the team advising the student.
ESM Graduate Program Learning Objectives: The Program Learning Objectives (PLO) describe what students will learn once they complete the program. The ESM PLO are:

- *Know:* Each student 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, neuroscience, and associated fields of research.
- *Create:* Each student will be able to synthesize theory, literature and experimental results to generate new concepts, designs or hypotheses in engineering science and mechanics.
- *Apply:* Each student 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.
- *Communicate:* Each student will be able to convey ideas or arguments in clear, concise, well-organized papers and proposals as well as in formal oral presentations.
- *Critical Thinking:* Each student will be able to critically analyze work by others in their field of specialty.
- *Professional Practice:* Each student will demonstrate the ability to collaborate in a collegial and ethical manner with other professionals within their field and/or with diverse scientific backgrounds.

3.1.2 Objective and scope of the ESM Qualifying Examination

In the ESM Graduate Program, the goals of the QE are:

- To assess students' potential to excel in their Ph.D. studies and to conduct research at the highest level. Passing the QE is required to progress in the program (GCAC-604).
- To assess early the students' mastery of skills and knowledge in their field as well as their ability to incorporate the ESM PLO into their research.
- To assess the English language competence of both domestic and international students (GCAC-605), in both written and oral forms.
- To offer each Ph.D. student written recommendations for topical/skills/knowledge-based improvements and additional coursework along with recommendations for English competence improvements/remediation, when needed.

To achieve its goals, the QE will consist of oral and written components (detailed below) centered around the student's research interests. For the written component, the student will compile a document in the form of either a research proposal or an in-depth critical research literature review (detailed below). This written document is used in the oral component as a platform for the exam committee to probe the student's foundational knowledge and potential as a researcher.

3.1.3 Timeline of the Qualifying Examination

All students must take the QE within three semesters (not counting the summer semester) of entry into the doctoral program. Exams will be administered on a rolling basis throughout the year.

3.1.4 Eligibility for the Qualifying Examination

To be eligible to take the QE a student in the ESM graduate program must:

- Have secured an adviser (see 3.1.1).
- Have earned at least 18 credits (beyond baccalaureate degree) in courses that can be counted toward the graduate degree.
- Have a grade-point average of 3.00 or greater while a graduate student at Penn State.
- Have no incomplete or deferred grades at the time of requesting the QE.
- Be in good academic standing and be registered as a full-time or part-time graduate degree student for the semester (excluding summer session) in which the QE is taken.

3.1.5 Qualifying Examination Committee

The QE is administered by a student's Qualifying Examination Committee (QEC). The QEC is an *ad hoc* committee in the sense that a specific QEC is formed for each student. The QEC consists of three members of the ESM graduate faculty: two individuals whose research focus is aligned with that of the student's proposed research area and one individual whose research focus might be deemed outside of that of the student's proposed research area. This latter member will serve as the chair of the QEC. If germane to a student's field of study, and subject to the approval of the ESM Graduate Program Head, at most one member of the QEC can be substituted with a member of the Penn State graduate faculty not affiliated with the ESM Ph.D. program.

The QEC will assess a student's performance during the QE and offer recommendations for the benefit of the academic development of the student. For this reason, it is strongly recommended that students consider retaining some or all members of the QEC as members of their dissertation committee.

3.1.6 The Qualifying Examination Request Form

The plan to effect a QE is produced by filling out the Qualifying Examination Request Form (QERF; cf. Appendix X). Students can take their QE only upon approval of their QERF by the ESM Graduate Program. Head.

Filling out the QERF is a process involving the following parties:

a. The student requesting to take the QE.
b. The student's adviser.
c. The student's QEC.

Filling out the QERF requires the following steps:

i. The adviser, together with the student, will select a research focus for the QE thereby indicating the QE's general area of examination and general sources.

ii. The adviser will select the modality for the written component of the exam (cf. 3.1.7) and will indicate a specific area of examination complete with a list of specific sources.

iii. The adviser, along with the student, will propose a list of QEC members.

iv. After i.–iii. are complete, the student will contact the proposed QEC members and secure consent from enough individuals so to satisfy the requirement in 3.1.5 and thereby identifying the chair of the QEC

v. The student will survey the QEC members and the adviser to determine a date, time, and a place for the QE.

vi. Once the research focus of the QE is clear and the QEC is finalized, the student will obtain signatures from the members of the QEC confirming their participation in the QE at the appointed date, time, and place **(link to fillable QERF).**.

vii. Once the QERF is complete, the adviser will submit it to the ESM Graduate Program Head for approval.

3.1.7 Components of the Qualifying Examination

The QE will consist of two components: one written and one oral.

For the **written component** of the QE, students will compile a written document not to exceed 6 pages in length (single-spaced, 12pt font size, 1" margins), including graphics, tables, but excluding bibliography. The document must be submitted to the QEC at least two weeks prior to the oral component. The document can have one of two modalities:

i. a research proposal, or

ii. a critical literature review and analysis of some influential papers in the chosen research field.

As stated in 3.1.6, the modality is selected by the adviser and is reported on the QERF. The research proposal option will include a research problem statement, a statement of the rationale for the problem, a pertinent literature review that identifies knowledge gaps, and a research plan to fill specific knowledge gaps. The critical literature review and analysis must include the identification of knowledge gaps together with well-reasoned recommendations for further research. Again, the topic of the written document, along with papers to analyze and any additional reference materials, is indicated on the RFQE form.

Examples of both modalities are in Appendices X1 and X2.

The **oral component** of the QE will last approximately 100 minutes. The student will begin with a presentation of the material in the document compiled for the written component of the QE. This presentation should not exceed 20 minutes. The presentation will be followed by a question-and-answer period (approximately 60 minutes) in which the members of the QEC will probe the student's preparation vis-à-vis the goals of the QE (cf. 3.1.2). The remainder of the time will be taken by the QEC to deliberate the outcome of the QE.

3.1.8 Assessment of the QE

All Penn State current Academic Integrity policies (including Senate Policy 49-20 and Policy G-9) apply to the QE. Academic Integrity violations will result in failure of the exam.

The QEC assessment of a student's proficiency is separated into two distinct categories: (i) PLO, and (ii) English competence. Each of these components is assessed using a respective rubric. The two rubrics are in Appendix Z. Each rubric has its own set of subcategories rated according to the following scheme: excellent, very good, satisfactory, and unsatisfactory.

The members of the QEC will assign rating to each subcategory of each rubric. Each individual rating will be established by majority vote.

Students pass their QE if a rating of satisfactory or better is assigned to each subcategory of the PLO rubric. Students fail the QE if one or more of the subcategories of the PLO rubric is rated unsatisfactory.

Students will be considered to have demonstrated competence in the English language if a rating of satisfactory of better is assigned to each subcategory of the English competence rubric. Students are required to improve their proficiency in English if one or more of the subcategories of the English competence rubric is rated unsatisfactory.

In case of failure of the QE, the recommendation for the retake of the exam shall be made by the QEC and provided to the ESM Graduate Program Head who, in consultation with the student's adviser, will make a final determination. Retakes of the exam must be held within six months of the original exam with the same QEC. The research focus for the retake can be modified at the discretion of the adviser. Only one retake is allowed for each student. In preparation for the QE retake, it is highly recommended that the student, along with the adviser, meet with the chair of the QEC to review the exam results. Students who fail the QE (either once without option to retake, or twice) will be given the option to either leave the program or to pursue one of the ESM graduate degrees at the Master's level.

If a student fails to achieve English competence, suggestions for improvement that may include coursework will be given by the QEC. The student must then be retested by the QEC based on a revised version of the written document and oral presentation with questions limited to ascertaining English competence. It should be noted that English competence is necessary for scheduling the comprehensive exam.

Regardless of outcome, the QEC will provide written recommendations for topical/skills/knowledge-based improvements and additional coursework along with recommendations for English competence improvements/remediation, when needed.

3.1.9 Administrative Specifics for the Qualifying Examination

It is the responsibility of the QEC to administer the QE at a breadth and depth consistent with its goals. Furthermore, each member of the QEC is required to uphold the Penn State Values and abide by the highest professional and ethical standards.

The chair of the QEC (cf. 3.1.5) will be responsible for completing the QE Evaluation Form (Appendix Z) and submitting it to the ESM Graduate Program Head within two business days after the QE. This form records both the outcome of the exam and the written recommendations for the student.

It is the responsibility of the ESM Graduate Program Head to inform students and their advisers of the outcome of the exam within seven business days of the QE.

It is recommended that the student's adviser be present during the QE. The adviser's role during the QE will be limited to that of silent observer. Neither the student nor the adviser will be present during the QEC deliberation.

3.1.10 Dispute and Appeal

If the QE outcome is disputed by the student and/or adviser, the ESM Graduate Program Head will attempt to address the grievance informally, possibly by involving the QEC chair. If no satisfactory resolution is reached, the grievance will be escalated by informing the ESM Department Head, who will be responsible for offering a satisfactory resolution following the recommendations in policy GCAC-802 of the Penn State Graduate School. Students might also avail themselves of the Graduate Student Ombudsperson Program of the Penn State Graduate School.

3.1.11 Summary of responsibilities

Student:
- check eligibility to take QE (GPA, # of credits, DF, registration)
- together with the adviser select the research topic, committee members
- secure consent from each committee member, determine a date, time and place for the QE
- obtain signatures from the QEC members on QERF
- submit the written component to committee members 2 weeks prior to the exam

Adviser:
- Together with the student, select research focus for the QE
- Select the modality for the written exam
- Indicate a specific area of examination and a list of specific sources
- Propose a list of QE committee members
- Submit the completed QERF to the ESM graduate program (Ela/Ashley) for approval
- Attend the exam as a silent observer

QEC chair:
- Moderate the oral component of the exam following the prescribed timeline (presentation-20 min, Q and A -60 min)
- Lead the post-exam discussion to determine the outcome of the exam
- Fill the QE assessment rubrics
- Regardless of the outcome provide written recommendations for topical/skills/knowledge-based improvements, and additional course work along with English competence remediation when needed

- Submit the completed QE evaluation (see above) form to ESM program (Ela/Ashley) within 2 business days after the exam
- When contacted by the student/adviser discuss the outcome of the examination with them

Program Head:

- Review the QE assessment form
- Notify students and their advisers of the outcome of the exam within 7 business days of the QE
- Manage the dispute and appeal process when needed

3.2 - The Doctoral Committee

The Doctoral Committee is appointed by the dean of the Graduate School (upon recommendation of the Graduate Officer and with the cognizance of the thesis adviser), and is responsible for overseeing the candidate's program, as well as administering the oral comprehensive and the final oral examination. ***After notification about the successful completion of the Qualifying Exam, the student should form the doctoral committee within one year***. General guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of four or more active members of the Graduate Faculty, which includes at least two faculty members in the major field. The dissertation adviser must be a member of the doctoral committee. The dissertation adviser usually serves as chair, but this is not required. If the candidate is also pursuing a dual-title field of study, a co-chair representing the dual-title field must be appointed. In most cases, the same individual (e.g., dissertation adviser) is a member of the Graduate Faculty in both the major and dual-title fields, and in such cases may serve as sole chair.

At least one regular member of the doctoral committee must represent a field outside the candidate's major field of study in order to provide a broader range of disciplinary perspectives and expertise. This committee member is referred to as the "Outside Field Member." In cases where the candidate is also pursuing a dual-title field of study, the dual-title representative to the committee may serve as the Outside Field Member.
Additionally, in order to avoid potential conflicts of interest, the primary appointment of at least one regular member of the doctoral committee must be in an administrative unit that is outside the unit in which the dissertation adviser's primary appointment is held (i.e., the adviser's administrative home; in the case of tenure-line faculty, this is the individual's tenure home). This committee member is referred to as the "Outside Unit Member." In the case of co-advisers, the Outside Unit Member must be from outside the administrative home(s) of both co-advisers. In some cases, an individual may have a primary appointment outside the administrative home of the student's dissertation adviser and also represent a field outside the student's major field of study; in such cases, *the same individual may serve as both the Outside Field Member and the Outside Unit Member.*

If the candidate has a minor, that field must be represented on the committee by a "Minor Field Member". A person who is not a member of the Graduate Faculty (and may not be affiliated with Penn State) who is otherwise qualified and has particular expertise in the candidate's research area may be added as a "Special Member," upon recommendation by the head of the program and approval of the dean of the Graduate School (via the Office of Graduate Enrollment Services). A Special Member is expected to participate fully in the functions of the doctoral committee. If the Special

Member is asked only to read and approve the doctoral dissertation, that person is designated a Special Signatory. Occasionally, Special Signatories may be drawn from within the Penn State faculty in particular situations.

A faculty member from Engineering Science and Mechanics can serve as the outside field member provided their area of expertise is significantly different from those of the other committee members. The chair or one of two co-chairs must be in the Engineering Science and Mechanics major and is normally the faculty member who has agreed to supervise the thesis research.

As soon as the committee is formed students should contact the graduate programs assistant to complete the Doctoral Committee paperwork.

Each candidate should then prepare to meet with their doctoral committee to review past and future course work in relation to the proposed field of research; the first meeting will normally be called within one semester of the formation of the committee. Following this, the entire Ph.D. Committee should meet together with the student to conduct annual assessment, or if this arrangement is impossible, the student should meet individually with each member, at least annually. The meeting may be requested by the student or any member of the committee. The Ph.D. Committee's assessment report should be shared with the student and include his/her comments on the report. The completed annual assessment must be submitted by the Ph.D. Committee Chair to the Graduate Program Head.

3.3 - Course Requirements

The candidate's doctoral committee plays a major role in determining course requirements regarding the quantity and subject matter. However, certain minimum requirements are specified by the departmental graduate faculty depending on whether they are starting from a B.S. (or equivalent) or M.S./M.ENG. degree as follows:

1. Students may enter the Ph. D program after completing an M.S. degree or directly from the B.S. degree; the student starting from the B.S. degree will have a higher number of required credits.
2. The minimum number of course credits required for students entering the PhD program with a baccalaureate degree (see **Table 3-2A**):

    a) 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 (E MCH/E SC 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 (E MCH 524A or equivalent). Furthermore, at least one course (of at least 3 credits each) must be taken from each the following three categories: Mechanics, Materials, and Engineering Science (see Table 2-2).
    b) A minimum of 15 course credits must be in the major (courses with E MCH and/or E SC prefixes).
    c) A student must satisfy the seminar credit requirements for a total of 5 credits of ESC 514

d) Twelve credits of letter grade Thesis Research with E MCH/E SC 600 designation are required. Students are allowed to register for E MCH/E SC 600 credits beyond the 12 required, but these credits will receive a grade of "R" if successfully completed. Students are allowed to register for E MCH/E SC 600 credits only before passing the Comprehensive Examination, after which they must register for E MCH/E SC 601 for 0 credits.

3. Nine credits taken during each fall and spring semester (for students on half-time assistantships) should consist of course or research credits until the student has met the residency requirements (see section 3.5) of the Graduate School and has passed the comprehensive examination.

4. Those students who select a minor field of study must consult the department responsible for that field to determine requirements. A minor consists of no fewer than 15 additional credits.

5. A student pursuing the Ph.D. degree program directly from a B.S. (or equivalent) degree (hence, no M.S./M.ENG. degree) must satisfy **ALL** the coursework, seminar and thesis research credits for the M.S. degree, in addition to the requirements for the Ph.D. However, while a M.S. degree and thesis are not required, they are strongly recommended. A student identified as master's-along-the-way *upon admission into the Ph.D. program* must fulfill **ALL** requirements of the M.S. degree and may take the qualifying exam after the completion of the M.S. degree (see section 3.1).

Table 3-2A: Ph.D. Degree Requirements – Engineering Baccalaureate Degree Holder

Minimum number of course credits	**27**
Graduate seminar (E MCH/E SC 514)	**5**
Research credits (E MCH/E SC 600)	**12** credits of letter grades (additional research credits are allowed but without a letter grade)
Minimum number of total credits	**44**
Core courses required	E MCH 524A or equivalent, plus one course (of at least 3 credits) from each category: Mechanics, Materials, and Engineering Science
Maximum number of credits in 400-level courses	**6**
Minimum number of course credits at 500 level	**21**
Minimum number of E MCH/E SC credits	**15**
Qualifying examination	After earning 18 course credits (post B.S.) and no later than the 3rd semester in residency (not counting the summer session).
Comprehensive examination	Passed qualifying examination, have a minimum of 3.00 GPA, and satisfied the English competence Ideally it should be done the first semester following passing the QE
Culminating experience	Completion of dissertation and oral defense

6. As stated in Section 2 (**see Table 2-1),** the course requirements for the Master of Science degree in Engineering Science and Mechanics include a total of 24 course credits which must include 12 credits in the major (E MCH or E SC). The graduate faculty may from time to time announce groupings of courses recommended for the purpose of meeting this requirement. In addition, for a student entering PhD program with a M.S. degree:

    a) at least 18 graduate credits must be earned in 400- and 500- level lecture/laboratory courses approved by the department (only two 400 level courses may be taken)
    b) 3 credits of a graduate seminar (E MCH 514 or E SC 514) must be earned beyond the master's degree requirements

Table 3-2 B summarizes the above requirements.

Table 3-2B: Ph.D. Degree Requirements – M.S. Degree Holder

Minimum number of course credits	**18**
Graduate seminar (E MCH/E SC 514)	**3**
Research credits (E MCH/E SC 600)	**12** credits of letter grades (additional research credits are allowed but without a letter grade)
Minimum number of total credits	**33**
Core courses required	No special requirements
Maximum number of credits in 400-level courses	**6**
Minimum number of course credits at 500 level	**12**
Minimum number of E MCH/E SC credits	**12**
Qualifying examination	no later than the 3rd semester in residency (not counting the summer session).
Comprehensive examination	Passed qualifying examination, have a minimum of 3.00 GPA, and satisfied the English competence Ideally it should be done the first semester following passing the QE
Culminating experience	Completion of dissertation and oral defense

Initially, courses can be chosen from the list of suggested courses for the written component of the qualifying examination given in Table 3.1 (see sub-section 3.1.1).

3.4 - English Competence

A candidate for the degree of Doctor of Philosophy is required to demonstrate ***a high level of competence in the use of the English language, including reading, writing, listening, and speaking.*** That level of competence will be assessed through requiring a candidate to provide original writing (of a sufficient length and complexity) on a subject outside candidate's technical expertise and presenting and discussing this topic with a broad audience. This task will be achieved by writing a report on one of the ethics topics presented in the EMCH 514 seminar. Each candidate will be required to present and discuss his/her report during the first available date of the seminar meeting times. Each candidate will receive a grade on the written report and corresponding oral presentation which will be used to assess candidate's level of English language competence. If necessary, remedial course work and the use of the services of the English for Professional Purposes Intercultural Center (EPPIC) will be prescribed to the candidate.

3.5 - Academic Status and Residency Requirements

There is no required minimum number of semesters of study. However, over a twelve-month period, covering the interval between admission and the completion of the Ph.D. program, the candidate must spend at least two consecutive semesters, **exclusive of summer sessions**, as a registered full-time student engaged in academic work on the University Park Campus. **This Residency Requirement must be satisfied prior to the semester in which the final oral examination is administered.**

1. A student can be at most, a half-time graduate assistant to be classified as a full-time student during a semester. A semester in which a student is a three-quarter-time graduate assistant cannot be counted toward residency requirements. **NOTE: Regulations prohibit international students from being three-quarter time.**

2. A student is **NOT** permitted to register for E MCH/E SC 601, or E MCH/E SC 611 (no credit thesis preparation) until after residency requirements are satisfied and the comprehensive examination is passed.

3. International students are required by the Immigration and Naturalization Service (INS) to maintain normal progress. Those who are enrolled in less than full-time status during the fall or spring semesters must ask their adviser to notify, in writing, the University Office of Global Programs (previous name: International Students) for their INS record.

4. Students who are earning both an M.S. and a Ph.D. at Penn State are allowed 6 (M.S.) plus 12 (Ph.D.) research credits for a total of 18 research credits with a quality (letter) grade for thesis research (E MCH/E SC 600). All remaining credits will be graded as R (Research).

5. A full-time student (fall and spring) is defined as follows depending on their employment status (Graduate Assistant or GA):

    a. No employment—15 to 18 credits
    b. One-quarter time GA—9 to 14 credits
    c. One-half time GA—9 to 12 credits

6. Teaching Assistants are expected to register for 10 credits of graduate coursework. Permission must be granted from the ESM graduate officer for more or less credits. **NOTE: All students hired as Teaching Assistants (TA) are REQUIRED to be on campus and ready to begin working on the date specified on their signed contract until all course activities are finished including the Final Exam period. For Fall semesters, the start date is typically 1 week before the start of classes and the end date may extend a week after classes end. Failure to be on campus during this period is grounds to have the TA contract and all support terminated.**

3.6-The Comprehensive Examination

1. The candidate must have passed the qualifying exam and his/her English language competence must have been formally attested before taking the comprehensive examination.

2. The Comprehensive Examination may not occur before the completion of all course work required by the program and the Ph.D. Committee; it should be scheduled as quickly as possible following the passing of the Qualifying Examination.

3. The comprehensive examination can be oral, written, or both; it will be designed and given by the student's doctoral committee and scheduled by the Graduate School. The subject areas are broad and may cover any area related to the student's doctoral thesis. A written proposal of the intended thesis research will be required in advance of the oral part of the comprehensive examination

4. The responsibility for scheduling the Comprehensive Exam rests with the student and their Ph.D. committee chair.

5. The comprehensive examination may be held fully in-person or with partial remote participation. The student, adviser, and Ph.D. Committee Chair/Co-Chairs must be physically present for the examination. Other members of the Ph.D. committee may participate remotely with the agreement of the student and adviser. If the student, adviser, and/or committee chair/co-chair is not able to participate in-person due to extenuating circumstances, the Graduate Program Head may approve at their discretion the remote participation of one or more individuals or approve a fully remote examination.

6. The Graduate School requires a minimum of **two (2) weeks'** notification and hence, the candidate must contact the graduate programs assistant 3 weeks in advance to do the paperwork for comprehensive exam. If the candidates committee has *not* been officially formed, the candidate must contact the graduate programs assistant **4 weeks** in advance. Failure to have this done in the required time-frame may cause the exam to be delayed until the following semester.

7. The candidate must deliver to the doctoral committee a well-documented thesis research proposal, including a critical literature survey, scope, and objectives of the thesis research and approach at least **two (2) weeks** before the comprehensive examination. This proposal must be approved in writing by the thesis adviser prior to delivering it to the committee members.

8. Candidates are required to have a minimum grade point average of 3.00 for work done at the University at the time the comprehensive examination is given.

9. The student must be registered as a full or part-time degree student for the semester in which the comprehensive examination is taken.

10. A favorable vote of at least two-thirds of the members of the Ph.D. committee is required for passing the Comprehensive Examination.

11. A student who does not pass the Comprehensive Examination on the first attempt may be permitted by their Ph.D. committee to retake the examination, in its entirety. Failing twice will result in the student being asked to graduate with a master's degree (if all requirements for that degree are met by the student) and leave the program.

3.7 - The Final Oral Examination

The final oral examination for both M.S. and Ph.D. degrees are open to the public. While the examination is primarily related mainly to the thesis, it may cover the candidate's whole field of study without regard to courses that have been taken either at Penn State or elsewhere. The responsibility for scheduling the Final Oral Examination rests with the student in consultation with their Ph.D. committee chair.

The final oral examination (dissertation defense) may be held fully in-person or with partial remote participation. The student, adviser, and Ph.D. Committee Chair/Co-Chairs must be physically present for the examination. Other members of the Ph.D. committee may participate remotely with the agreement of the student and adviser.

If the student, adviser, and/or committee chair/co-chair is not able to participate in-person due to extenuating circumstances, the Graduate Program Head may approve at their discretion the remote participation of one or more individuals or approve a fully remote examination.

Once the date of the exam is finalized, the candidate needs to contact the graduate programs assistant 2.5 weeks in advance for the paperwork to be done.

Normally, the examination may not be scheduled until at least the semester after the comprehensive examination was passed. However, the dean of the Graduate School may grant a waiver in the case of an outstanding student. The thesis presentation should emulate the presentation of a paper at a technical session of a national professional meeting as follows:

The final oral examination shall consist of a public oral presentation of the dissertation followed by a closed discussion between the student and the student's Ph.D. Committee.

1. The presentation should be delivered within a definite time period—roughly 30-45 minutes for a Ph.D.

2. The talk should have been rehearsed with the actual visual aids prior to the presentation in order that the time limitations can be verified.

3. The presentation should proceed without interruption from the audience.

4. All questions to the examinee must be answered by the examinee.

It is important to note that an excessively long presentation may result in rejection by the committee. Additionally, examinees should be able to address the novel contributions of their research, its strengths, the challenges that were addressed, and future research directions.

When the candidate delivers the draft of the thesis to each member of their doctoral committee, a determination of the dates available for the final oral examination should be made and (with the concurrence of the chair) a request should be filed with the department's graduate officer for transmittal to the dean of the Graduate School of the examination date. Forms for this are in the main

ESM office. The transmittal date must be a minimum of two and one-half weeks after delivery of the thesis. **No exceptions are permissible.** Students are responsible for having drafts of their theses pre-checked by the Graduate School's Thesis Office by the deadline specified by the Graduate School. This will allow the student to be cleared for graduation and to remain on the graduation list. The student must be registered with full or part-time status for the semester the thesis examination is scheduled.

A favorable vote of at least two-thirds of the members of the committee is required for passing the examination. In the case of failure, it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. The doctoral committee will also determine if there is a limit on number of attempts, and in case of failure of the final attempt, if a student is allowed to change to the master's degree or will be dismissed from the program.

After the examination, it shall be the responsibility of the thesis adviser to determine whether the candidate has responded appropriately to the suggestions of the committee members in regard to the thesis.

3.8 - The Thesis

The thesis must represent a significant contribution to the field of study and be presented in a scholarly manner. It must also reveal an ability on the part of the candidate to do independent research of high quality and demonstrate considerable experience in using a variety of research techniques.

The student is responsible for providing a copy of the dissertation to each member of the Ph.D. committee at least two weeks prior to the scheduled date of the final oral examination.

Each thesis must contain a nontechnical abstract as the last appendix to explain the contributions reported in the thesis in terms that members of the general public may understand.

The dissertation must meet editorial standards specified by the Graduate School so that it constitutes an official University record for inclusion in the University Libraries and to be available to the public.

A completed thesis must be delivered to the Graduate School prior to the commencement when the candidate expects to receive the degree, per the deadline specified by the Graduate School. Moreover, the completed thesis must incorporate any changes decided upon at the final oral examination. It must be accompanied by two separate copies of an abstract.

Prior to commencement, the student shall deliver to the department office two acceptable copies of his/her thesis (one copy for the department file and the other for the adviser), bound in accordance with the requirements as detailed in the Graduate School's Thesis Guide. The Thesis Guide may be found at: https://gradschool.psu.edu/completing-your-degree/thesis-and-dissertation-information/ Copies may be purchased at the Thesis Office, 211 Kern Building. Costs incurred with thesis binding are the responsibility of the student.

Taking both the dissertation and the final oral examination into consideration, the Ph.D. Committee evaluates the accomplishments of the student relative to the program's defined Learning

Objectives, particularly with respect to the student's mastery of the major.

Program Learning Objectives (PLO)
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

3.9.- Master's-along-the-way

Students enrolled in a Ph.D. program of study may add research master's degree in the same major as their doctoral studies. The procedure to do it is presented in the graduate school policy GCAC 209 masters-along-the-way

a) A Ph.D. student may enroll in a master's-along-the-way (MATW) after the first semester in the Ph.D. program, but a master's-along-the-way cannot be added after the Comprehensive Examination has been passed.
b) Students must be enrolled in the master's-along- the-way no later than the semester ***prior to*** the semester in which the master's degree will be conferred and notify Program Coordinator, Mrs. Ashley Cecil aec5731@psu.edu about their intent.
c) Students must be enrolled in the master's degree ***in the semester before*** the master's degree will be conferred.
d) In the semester that all degree requirements will be completed, and the degree is to be conferred, the student should activate their Intent to Graduate in LionPATH by the published deadline for the graduation semester.

If the students are officially (on their LionPATH record) enrolled in the MS and the PhD at the same time (master's-along-the-way), all courses taken from the entry into the PhD program may count toward the MS until the student graduates with the MS.

ESM MATW program requires students to follow **all** the degree requirements for MS with thesis option (please see point 2.1.1 in the graduate guide for general overview). Specific course requirements are listed in Table 2-1. In addition, students must have secured an adviser.
After conferral of MS degree, to continue with their PhD studies, the student will need to take 9 more course credits, 3 EMCH/ESC 514 seminars and ESC/EMCH 600 research credits for a total of 12.
Please consider before enrolling in MATW
All students willing to set on the MATW path are advised to discuss this step with their advisers since it will require taking additional courses and prolonging their time in the program.

3.10 – Time Limitation

A doctoral student is required to complete the program including acceptance of the doctoral thesis within eight years (not including approved leave of absence) from the date of acceptance as a candidate (= successful completion of QE).

Extensions may be granted by the dean of the Graduate School in appropriate circumstances.

When a period of more than six years has elapsed between the passing of the comprehensive examination and the completion of the program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

3.11 - Continuous Registration Requirement

It is expected that all graduate students will be properly registered at a credit level appropriate to their degree of activity (see I-4 Registration.). After a Ph.D. candidate has passed the comprehensive examination and met the two-semester full-time residence requirement, the student must register continuously for each fall and spring semester (beginning with the first semester after both of the above requirements have been met) until the Ph.D. thesis is accepted and approved by the doctoral committee. Note that students who are in residence during summers must also register for sessions.

If the final oral examination or comprehensive examination is held during summer, registration is required.

Post-comprehensive Ph.D. students can maintain registration by registering for credits in the usual way or by registering for noncredit E SC or E MCH 601 or 611, depending upon whether they are devoting full time or part time to thesis preparation. Students are permitted to register for E SC or E MCH 514 (colloquium), E SC or E MCH 602 (supervised experience in college teaching), and audits along with E SC/E MCH 601. Students who want to combine course work with thesis preparation must register for E SC or
E MCH 600 or 611 (i.e., not for 601, which is full-time thesis preparation). Note that the least expensive way for a post comprehensive exam Ph.D. student to work full time on research and thesis preparation is to register for E SC or E MCH 601. This is the procedure of choice for international students who need to maintain status as full-time students for visa purposes.

If a Ph.D. student will not be in residence for an extended period for compelling reasons, the graduate dean will consider a petition for a waiver of the continuous registration requirement. The petition must come from the doctoral committee chair and carry the endorsement of the department or

program chair. This option offers a substantial savings in tuition. International students are still subject to INS (Immigration and Naturalization Service) rules regarding their student status.

ESM Ph.D. Program Quick Reference

1. Admission to grad program. Begin working (courses) toward Ph.D. Program
2. Qualifying Exam · given twice yearly (August/September and January)
3. Thesis committee selection and appointment · notify graduate staff assistant of committee selection · Graduate Staff Assistant notifies Graduate Officer of committee selection · minimum of four members of graduate faculty, of whom three must be from ESM faculty, and a minimum of one from the graduate faculty of a related field · student registers for E MCH/E SC 600 series thesis research credits prior to completing the comprehensive exam
4. Meet with doctoral committee within one semester of formation
5. Preparation of research objectives
6. Fulfillment of course requirements
7. Residency requirement · nine (9) credits minimum
8. Comprehensive exam · after completion of all course work required by the program and the Ph.D. Committee-check with Ph.D. adviser for approval. Student notifies Graduate Staff Assistant, in writing, who in turn notifies the Graduate School. Graduate School requires two (2) weeks' notice · student supplies committee members (2 weeks prior) with well documented research proposal. Communications and English competency requirement must be met prior scheduling comprehensive exam. After oral comprehensive exam student may register for E MCH/E SC 601.
9. Continuous registration · must register continuously each semester (excluding summers) beginning with the semester following the passing of comprehensive examination and continuing each semester until final oral examination is passed. Must register the semester of the qualifying comprehensive and final oral examinations - even if taken during summer session
10. Final oral exam (thesis defense) · notify Graduate Staff Assistant who in turn notifies Graduate School · date must be at least **two (2) weeks** after delivery of thesis to thesis committee · seven (7) weeks before degree conferral · three or more months must have elapsed between the passing of comprehensive examination and scheduling of the final oral examination
11. Deliver thesis electronically to Graduate School plus two bound copies of thesis to department two weeks prior to Commencement. Every thesis must contain a nontechnical abstract in addition to the usual technical abstract.
12. Time limitation · all requirements including submission of the thesis must be completed within eight years of qualifying examination date. The student must schedule a meeting with the ESM Graduate Officer every semester to determine if program requirements are being met. The student must also communicate with the Research Adviser at least biweekly.

Chapter 4: Joint M.D./Ph.D. in Engineering Science and Mechanics Degree Program

4.1 - Joint M.D./Ph.D. in Engineering Science and Mechanics Degree Program (M.D./Ph.D. ESMCH)

The Engineering Science and Mechanics (ESM) Department and the College of Medicine (COM) offer a joint degree program in which a student can receive an M.D. degree from the College of Medicine and a Ph.D. degree in Engineering Science and Mechanics from the College of Engineering (M.D./Ph.D. ESMCH). The Joint M.D./Ph.D. ESMCH Degree Program forms the basis for an interdisciplinary, transformational program dedicated to educating a new generation of ***Physician Engineering Scientists***, working at the frontiers of clinical and translational research.

Students in the Joint M.D./Ph.D. in Engineering Science and Mechanics degree program will complete 4 years of medical studies (designated years M1 through M4) in 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 spring of M2. After successful completion of 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 apply for admission to the Ph.D. program in Engineering Science and Mechanics.

Students will complete all 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. However, there are some 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 (21% of the total graduate credits) toward graduate course credit for the Ph.D. ESMCH degree;
- students admitted to the program with a master's degree will be allowed to double count 7 professional credits (21% of the total graduate credits) toward graduate course credit for the Ph.D. ESMCH degree.

A minimum grade-point average of 3.00 for work done at the University after admission is required for doctoral candidacy, admission to the Comprehensive Examination, the Final Oral Examination, and for graduation. ***It should be noted that passage of the Final Oral Examination is necessary, but it is not sufficient for award of the degree as the dissertation must also be accepted as the ultimate step.***

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 (E SC/E MCH 600/610) toward professional credits for the M.D. degree; and, master's degree holders will be allowed to double count 5 research credits (E SC/E MCH 600/610) 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. ESMCH degree 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. ESMCH degree program may take the Qualifying Examination within 3 semesters of entry into the Ph.D. program (expected to be the Fall Semester of G2).

Upon successfully completing the Qualifying Examination, students should appoint their doctoral committee as discussed in Chapter 3, Section 3.2.

The Comprehensive Examination may be taken in a semester following the Qualifying Examination, and must be completed at least one semester prior to submission of the dissertation.

Students must prepare and submit a scholarly dissertation that demonstrates comprehensive and in-depth knowledge of a topic in Engineering Science and Mechanics. The contents and conclusions of the dissertation must be defended at the time of the Final Oral Examination. The scholarly research should be suitable for submission for publication in a refereed journal as approved by the student's adviser(s). Normally, the Final Oral Examination may not be scheduled until at least three months after the Comprehensive Examination.

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.

4.2 - Current Requirements for the Ph.D. Degree in Engineering Science and Mechanics (Ph.D. ESMCH)

Students may enter the Ph.D. program after completing an appropriate baccalaureate or master's degree prior to admission.
As detailed in Chapter 3, candidates for the Ph.D. degree in Engineering Science and Mechanics typically take a minimum of 44 total credits beyond the baccalaureate degree (27 graduate course credits, 5 seminar credits, and typically 12 research credits). Master's holders typically take 33 credits (18 graduate course credits, 3 seminar credits, and up to 12 research credits). Exceptions to these requirements may be approved by petition.

Students must demonstrate English proficiency, pass a Qualifying Examination, a Comprehensive Examination, as well as a Final Oral Examination. A doctoral dissertation on an appropriate topic is required. It must be a well-organized account of research undertaken by the student and show initiative and originality. A minimum grade-point average of 3.00 for work done at the University is required for doctoral candidacy, admission to the Comprehensive Examination, the Final Oral Examination, and for graduation. It should be noted that passage of the Final Oral Examination is necessary, but it is not sufficient for award of the degree; the dissertation must be accepted, as the ultimate step. Please refer to Chapter 3 for more details.

4.3 - Current College of Medicine Graduation Requirements

The current Medical School graduation requirements are described below:

1. Satisfactory completion of all Year 1 required courses.
2. Completion of the Year 1 Objective Structured Clinical Examination (OSCE).
3. Satisfactory completion of all Year 2 required courses.
4. Completion of the Year 2 OSCE.
5. Satisfactory completion of all Year 3 required clerkships, 3 Island courses, and 1required elective month.
6. Satisfactory completion of the Year 3 choice procedures by the end of Year 3.
7. Passing score on the Year 3 OSCE.
8. Completion of the Medical Student Performance Evaluation (MSPE); a requirement for residency application.
9. Satisfactory completion of all Year 4 required acting internships, Neurology clerkship, Year 4 Island, the Humanities requirement, and 4 electives.
10. Passing score on the United States Medical Licensing Examination (USMLE) Step 1.
11. Passing score on USMLE Step 2 Clinical Knowledge.
12. Passing score on USMLE Step 2 Clinical Skills.
13. Completion of the Medical Student Research (MSR) Project.
14. Observed History and Physical Examination:
    - Completed during the acting internship or the electives taken during the 4th year of medical school.
    - Complete 2 examinations that must be signed off by an attending physician, chief resident or a fellow.

4.4 - Joint Program Requirements

The Joint M.D./Ph.D. in Engineering Science and Mechanics Degree Program will require 4 years of medical study (Years M1 through M4) and 3 or more years of graduate study (Years G1 through G3 or GX) in Engineering Science and Mechanics fields. While there will be some level of double-counting of courses, the candidates will fulfill the full requirements of both programs as detailed below.

4.4.1 - Overview of Program Requirements for the Joint M.D./Ph.D. ESMCH Degree

Program-specific requirements for the Joint M.D./Ph.D. in Engineering Science and Mechanics are listed below:

- Students must demonstrate English proficiency, pass a Qualifying Examination, a Comprehensive Examination, and a Final Oral Examination.
- Students may enter the Joint M.D./Ph.D. program with an approved baccalaureate or master's degree.
- Students must successfully complete the first and second year of the M.D. curriculum (Years M1 and M2) and Step 1 of the United States Medical Licensing Examination (USMLE)

before applying for admission to the graduate program in Engineering Science and Mechanics (.

- Baccalaureate degree holders may double count 9 professional credits (equivalent to 21% of the total graduate credits) approved by the ESM Graduate Faculty toward graduate course credit for the Ph.D. ESMCH degree.
- Master's degree holders may double count 7 professional credits (equivalent to 21% of the total graduate credits) approved by the ESM Graduate Faculty toward graduate course credit for the Ph.D. ESMCH degree.
- In the summer between Years M1 and M2, students may complete a laboratory rotation in Engineering Science and Mechanics and apply 3 graduate credits toward the Ph.D. ESMCH degree.
- Students will undertake graduate studies in Engineering Science and Mechanics in Years G1 through GX.
- For baccalaureate degree holders, graduate study in the summer between Years M1 and M2 and in Years G1-GX will require 21 credits of graduate course work, 2 credits of seminar, and 12 credits of thesis research (E SC/E MCH 600/610). The selected course work must comply with the requirements for the M.S. and Ph.D. degrees in Engineering Science and Mechanics.
- Each student's program will be customized according to research interests and approved by the research adviser and ESM Graduate Officer.
- For master's degree holders, graduate study in the summer between Years M1 and M2 and in Years G1-GX will require a minimum of 18 credits of graduate course work to satisfy the requirements for the Ph.D. degree in Engineering Science and Mechanics, 2 credits of seminar, and 6 credits of thesis research (E SC/E MCH 600/610). Each student's program will be customized according to research interests and approved by the research adviser and ESM Graduate Officer.
- Students will complete 5 hours of required SARI (Scholarship and Research Integrity) training for the Responsible Conduct of Research (RCR) through the E SC/E MCH 514 Seminar series and via special workshops, as opportunities arise.
  At least 3 seminars/workshops will be offered each fall; 2 seminars/workshops each spring will be devoted to discussion-based RCR education via the E SC/E MCH 514 seminar class, special workshops, guest speakers, and/or example/case study followed by directed RCR discussions.
- 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).
- Upon successfully completing the Qualifying Examination, students should appoint their doctoral committee.
- Students are expected to focus on research following completion of all course work.
- For baccalaureate degree holders, 10 research credits (E SC/E MCH 600/610) applied toward the Ph.D. ESMCH degree will be double counted toward the professional M.D. degree.
- For master's holders, 5 research credits (E SC/E MCH 600/610) applied toward the Ph.D. ESMCH degree will be double counted toward the professional M.D. degree.

- Students may take the Comprehensive Examination in a semester following the Qualifying Examination. The Comprehensive Examination must be completed at least one semester prior to submission of the Ph.D. dissertation.
- Students must prepare and submit a scholarly dissertation that demonstrates comprehensive and in-depth knowledge of a topic in Engineering Science and Mechanics. The contents and conclusions of the dissertation must be defended at the time of the Final Oral Examination. The scholarly research should be suitable for submission for publication in a refereed journal as approved by the student's adviser(s). Normally, the Final Oral Examination may not be scheduled until at least three months after the Comprehensive Examination.
- 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.

4.4.2 - Professional/Graduate Credits (M.D.)

For **baccalaureate** degree holders, the ESM Department will accept (double count) 9 credits of professional medical course work (21% of the total credits) appropriate to the student's research focus toward the Ph.D. degree in Engineering Science and Mechanics (Ph.D. ESMCH) as shown in **Table 4-1**. For example, credits from the following courses could be double counted: BMS 506 A (2 credits), BMS 506B (2 credits), and either HMN 713 (Medical Humanities; 5 credits) or SHS 711 (Health systems; 6 credits).

In Table 4.1 the professional credits to be double counted by ESM are highlighted in green and the graduate credits to be double counted by the College of Medicine are highlighted in yellow.

Table 4-1: Joint M.D./Ph.D. ESMCH - Engineering Baccalaureate Degree Holders

Year	Fall Semester	Spring Semester	Credits	
M1	MD Curriculum (25 professional credits)	MD Curriculum (26 professional credits)		
	Professional Course (dual graduate credits: 9)		9	Professional
Summer	E SC/E MCH 596 or E SC/E MCH 600 Laboratory Rotation (3 graduate credits)		3	Graduate
M2	MD Curriculum (32.5 professional + 2 graduate credits)	MD Curriculum (33 professional + 2 graduate credits)		
G1	ESM Approved Graduate Courses (9 credits)	ESM Approved Graduate Courses (9 credits)	18	Graduate
	E SC 514 or E MCH 514 Seminar (1 credit)	E SC 514 or E MCH 514 Seminar (1 credit)	2	Seminar
G2	ESM Approved Graduate Courses (10 credits)	E SC/E MCH 600/610 Research (6 credits)	12	Graduate Research
G3-GX	E SC/E MCH 600/610 Research (3 credits)	E SC 601 Thesis Preparation (0 credit)		
M3	MD Curriculum (~36 credits)	MD Curriculum (~36 credits)		
M4	MD Elective Credits (~10 credits)	MD Elective Credits (~11 credits)		
	10 credits E SC/E MCH 600/610 from G2 and G3 (dual professional credits)		**44**	**Total**

For **baccalaureate** degree holders, the College of Medicine's Medical Curriculum Oversight Committee for Years 3 and 4 (CUMED III/IV) will accept (double count) 10 credits of E MCH 600 or E SC 600 (Thesis Research) or E MCH 610 or E SC 610 (Thesis Research Off Campus) in lieu of two 5-credit medical research electives in Year M4 of the professional M.D. curriculum.

Table 4-2: Joint M.D/Ph.D. ESMCH – Entering Master's Degree Holders

Year	Fall Semester	Spring Semester	Credits	
M1	MD Curriculum (25 professional credits)	MD Curriculum (33 professional credits)		
	Professional Course (dual graduate credits: 7)		7	Professional
Summer	E SC/E MCH 596 or E SC/E MCH 600 Laboratory Rotation (3 credits)		3	Graduate
M2	MD Curriculum (34.5 professional credits)	MD Curriculum (35 professional credits)		
G1	ESM Approved Graduate Courses (9 credits)	ESM Approved Graduate Courses (6 credits)	15	Graduate
	E SC 514 or E MCH 514 Seminar (1 credit)	E SC 514 or E MCH 514 Seminar (1 credit)	2	Seminar
G2	E SC/E MCH 600/610 Research (6 credits)	E SC 601 Thesis Preparation (0 credit)	6	Research
G3-GX	E SC 601 Thesis Preparation (0 credit)	E SC 601 Thesis Preparation (0 credit)		
M3	MD Curriculum (~36 credits)	MD Curriculum (~36 credits)		
M4	MD Elective Credits (~10 credits)	MD Elective Credits (~11 credits)		
	5 credits E SC/E MCH 600/610 from G2 (dual professional credits)		**33**	**Total**

For **Master's** degree holders, the College of Medicine's Medical Curriculum Oversight Committee for Years 3 and 4 (CUMED III/IV) will accept (double count) 5 credits of E MCH 600 or E SC 600 (Thesis Research) or E MCH 610 or E SC 610 (Thesis Research Off Campus) applied toward the Ph.D. ESMCH degree in lieu of one 5-credit medical research elective in Year M4 of the professional M.D. curriculum. Note: the six research credits (E MCH/E SC 600/610) used to satisfy the requirements for the M.S. ESMCH cannot be used toward the M.D. degree).

Students may take the Qualifying Examination after successful completion of 18 credits of approved graduate course work. Master's degree holders accepted into the Joint M.D./Ph.D., ESMCH program may take the Qualifying Examination in the Spring Semester of Year G1 and no later than the Fall Semester of G2. Baccalaureate degree holders accepted into the Joint M.D./Ph.D., ESMCH program may take the Qualifying Examination before the end of the third semester of entry into the Ph.D. program, expected to be the Fall Semester of G2.

For **master's** degree holders, the ESM Department will accept (double count) 7 credits of professional medical course work (22% of the total graduate credits) toward the Ph.D. degree in Engineering Science and Mechanics (Ph.D., ESMCH) as shown in **Table 4-2**.

4.5 - Admission Process and 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 in the College of Medicine. It is anticipated that the ESM Department Head, or designee, will serve on the M.D./Ph.D.

Admissions Committee, and the ESM Graduate Officer, or designee, will serve on the M.D./Ph.D. Steering 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 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 for admission to the graduate program after successful completion of the first 2 years of medical school, including all required rotations, and Step 1 of the United States Medical Licensing Examination (USMLE). For admission to the Graduate School, an applicant must hold either (1) a bachelor's degree from a U.S. regionally accredited institution or (2) a postsecondary degree that is equivalent to a U.S. baccalaureate degree earned from an officially recognized degree-granting international institution. International applicants must hold the equivalent of an American four-year baccalaureate degree. Graduates in engineering, the mathematical sciences, mathematics, engineering science, and materials science and engineering who present a 3.5 grade-point average will be considered for admission. Exceptions to the minimum 3.5 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants will be accepted up to the number of places available for new students.

Scores from the Graduate Record Examination (GRE) are not required for admission.

International applicants must take and submit scores for the TOEFL (Test of English as a Foreign Language) or IELTS (International English Language Testing System). The minimum composite score for the IELTS is 6.5. The minimum score accepted for the internet-based test (iBT) is 80 (total), with a 19 on the speaking section.

International applicants who have received a baccalaureate or a graduate degree from a college/university/institution in the following countries are exempt from the TOEFL/IELTS requirement: Australia, Belize, British Caribbean and British West Indies, Canada (except Quebec), England, Guyana, Republic of Ireland, Liberia, New Zealand, Northern Ireland, Scotland, the United States, and Wales.

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

Chapter 5: Engineering Mechanics as a Minor

M.S. degree students outside the Engineering Science and Mechanics department wishing to minor in Engineering Mechanics are expected to take 9 credits of 500-series lecture courses in Engineering Mechanics. ***A member of the ESM faculty <u>MUST</u> serve on the student's thesis committee.***

Students desiring a minor must have their major program notify the Graduate Programs Office via the Department of Engineering Science and Mechanics of their intent to complete a specific minor. The department will verify that the minor requirements have been met at the time the student graduates. Completion of the minor is recorded on the student's transcript.

For Ph.D. students, the minor must consist of no fewer than 15 credits including those applied toward a master's degree and must meet the approval of the Engineering Science and Mechanics graduate faculty. Students are required to take at least 12 credits of E MCH 500-series lecture courses, not including E MCH 514 and E MCH 596, and will be examined on this course work during the comprehensive exam by the faculty representing the Engineering Mechanics minor. Completion of the minor will appear on the student's transcript.

Chapter 6: Concurrent Graduate Degree Candidacies

Occasionally a candidate for an advanced degree in one major field may desire to begin work on either a master's or a doctoral degree in a second field before completing the first program. In this event the student will consult with both graduate program heads and, under their direction, draw up a program of study to meet the requirements of the two degrees. Any common agreements, such as the required completion of one program before advancing beyond a specified point in the other, should be added to the stated program of study as part of the agreement before it is approved, signed by the representatives of each degree, and sent to the Office of Graduate Programs for review. The Office of Graduate Programs will verify that degree requirements in both programs will be met by the proposed plan of study and that overlap between the programs is not excessive.

Additional concerns such as credit requirements, examining procedures, project/paper or thesis content and conferral of degrees is available from the graduate officer.

Chapter 7: Graduate Assistantships

The graduate assistantship (Research Assistantship (RA) or Teaching Assistantship (TA) is a vehicle for providing a stipend to help meet living and other incidental expenses during graduate study. In exchange for this stipend (and also the remission of tuition fees) the student is expected to assist in the teaching and/or research programs of the department. For the purposes of codification, this effort is assessed using a forty-hour week as a nominal "full-time" effort, so that a "half-time" assistantship (the usual arrangement) implies a commitment to an average of twenty hours per week of effort for the entire semester (eighteen weeks).

Note: all students hired as Teaching Assistants (TA) are REQUIRED to be on campus and ready to begin working on the date specified on their signed contract. For Fall semesters, the start date is one week before classes start. Additionally, the student must remain until all course related activities are finished including the grading of final exams and/or projects; this usually extends to the finals week after classes have ended. Failure to be on campus during the required time period is grounds to have the TA contract and all support terminated.

It is in the best interests of the student and the department that the student progress to graduation in a timely fashion. Under normal circumstances, an M.S. student should achieve the requisite credits as a half-time graduate assistant in three semesters (2 for IUG students); a Ph.D. student should achieve all required credits beyond the M.S. degree in six semesters.

Although very rare, summer session of support is roughly equivalent to two-thirds of a semester.

In order to conserve the resources of the University, College, and Department, all requests for graduate assistantships beyond these time limits will be closely examined for evidence of satisfactory progress, even if a student is funded as a Research Assistant (RA).

In the event an individual has reached or exceeded these limits (regardless if the funding was for a research assistantship or for a teaching assistantship or some combination thereof), the department will not provide teaching assistantship funding except in the most unusual situations. As such, students being supported on assistantships should plan accordingly.

Outside Employment—A student holding any fellowship, graduate assistantship, and/or scholarship may not normally accept employment of any kind beyond that specified by his or her appointment. International students may not seek outside employment under any circumstances unless approved by the INS.

Academic Load—Graduate assistantships are awarded to enrolled Penn State graduate students. The Graduate School regulates both the maximum and the minimum number of course credits a graduate student may take according to the schedule in **Table 7-1**.

Students must satisfy the minimum course requirement to retain their assistantship and are strongly encouraged to carry maximum credits.

International students must carry a full-time load.

Further explanations of Graduate School policies can be found in the Penn State Graduate Degree

Programs Bulletin http://bulletins.psu.edu/bulletins/whitebook/index.cfm.

Table 7-1: Graduate Assistantship

Graduate Assistantship	Employment hours per week	Credits to be taken Fall/Spring Semesters *	Credits to be taken Summer Session
	None	15-18	5-12
¼ time	10	9-14	5-7
½ time	20	12	4-6
¾ time	30	6-8	3-4

*Courses taken for audit do not count toward the minimum credit load but do count toward the maximum credit load.

Periods of Appointment—Appointments cover eighteen (18) weeks each academic semester. Start and termination dates may be varied by agreement between the student and the Graduate Officer, in collaboration with the student's adviser. In the absence of a specific agreement to the contrary, the period of appointment is 20 weeks ending on commencement day, or an equivalent date, of the semester in question.

Payments—Payments are made on the last working day of the month. Unsatisfactory performance of graduate assistantship duties will result in a summary suspension of payments.

Office/Desk Assignments—Office/desk assignments for research assistants are made by the supervising faculty member. Assignments for teaching assistants are made by the department head on a semester-by-semester basis. Students need to confirm their assignments at the beginning of each semester.

Electronic Employment Bulletin Board

It is advisable for all students to visit Penn State's Career Services in person at the Bank of America Career Services Center located on the corner of Bigler and Eisenhower Road or on-line at http://studentaffairs.psu.edu/career/.

Chapter 8: Teaching Assistant Responsibilities

A Teaching Assistant (TA) in the Department of Engineering Science and Mechanics may be assigned any (or a combination) of the following assignments:

- Classroom recitation
- Classroom laboratory leadership
- Homework, project, and/or test grading
- Tutoring
- Office hours to assist students

Teaching assistants are supervised by a faculty member who assigns specific duties, mentors the teaching assistant throughout the semester, and supervises the teaching assistant's performance. Teaching assistants are also required to participate in an instructional development program (ENGR 888 with details to be provided prior to the semester in which the teaching assistant is assigned teaching responsibilities) as established by the University and the College of Engineering.

All international teaching assistants are required to take and pass an oral proficiency test (AEOCPT). A modified version of the oral language SPEAK test is administered through Penn State's Center for English as a Second Language, 305 Sparks Building. Students must be preregistered for the exam and may do so by calling the center at 865-7365. This may be done upon the student's arrival at Penn State. It is the center's policy to give the test only once. If a student wishes to take the test a second time, he or she may take it through the Educational Testing Services (see below for address).

Note: The Test of Spoken English (TSE), if available, may be taken in a student's home country.

Applications for the TSE may be obtained from:

Educational Testing Services (ETS)
Box 899
Princeton, NJ 08541

Results should be forwarded to:

The Center for English as a Second Language
305 Sparks Building
University Park, PA
16802

New Teaching Assistants are required to attend an orientation meeting, to be determined by the course coordinator, at the beginning of the Fall semester. New graders have a separate orientation meeting. Every new TA, with tasks other than grading, must take ENGR 888 in the first semester.

Chapter 9: Changing Programs

Students who decide that their academic and research interests would be better met under the auspices of a program other than those offered through the Engineering Science and Mechanics department are first encouraged to discuss their intentions with their academic adviser and the graduate officer. In the event a change of program is the best course of action, students must request a major change by processing a Change of Major Form through the Graduate Programs Office in 114 Kern Graduate Building. This request to change programs will then be forwarded to the chairs (or advisers) of both the prospective program and the current program. The chairs (or advisers) of both programs will review the proposed change prior to making a final decision.

Chapter 10: Health Insurance

Penn State requires medical insurance for all graduate assistants, for all international students, and for all dependents of international students while in the U.S.. Please visit the websites of the Student Insurance Office for more information.

1. http://studentaffairs.psu.edu/health/services/insurance/

2. http://studentaffairs.psu.edu/health/services/insurance/graduate.shtml

Chapter 11: International Students

Immigration and Naturalization Service (INS) continually updates its rules and regulations. An international student must remain in compliance with all INS regulations at all times. It is the student's responsibility to be aware of the student's obligation. Information can be found at University Office of Global Programs (formerly: Office of International Programs) web site: http://global.psu.edu/.

All incoming International Students (TA, RA, or self-supported) are required to take the AEOCPT (American English Oral Communication Proficiency Test) administered by the Department of Linguistics, the first semester they are in residence. If the student does not pass the test with a score above 250, then they are required to take an English as a Second language (ESL) course based on their AEOCPT score as outlined below:

250-300	None. Student may assume teaching duties with no restrictions.
200-249	Enroll in **ESL 118G** *before* assuming teaching duties. *Students enrolled in ESL 118G must pass the course with a grade of "A" and pass the qualifying exit examination, called the Interactive Performance Test (IPT), before they can assume teaching duties with no restrictions.*
150-199	Enroll in **ESL 117G**. Will require at least two semesters before student is recommended to teach. *Students enrolled in ESL 117G must receive a grade of "A" before they will be allowed to enroll in ESL 118G.*
below 150	Enroll in **ESL 115G** Will require at least three semesters before student is recommended to teach. *Students enrolled in ESL 115G must receive a grade of "A" before they will be allowed to enroll in ESL 117G. Then must receive a grade of "A" in ESL 117G before they will be allowed to enroll in ESL 118G.*

If you will be a RA or are self-supported and receive a score lower than 250 on the AEOCPT or you are admitted under a provisional status (your TOEFL does not meet the minimum Graduate School requirement), you will be required to take English as a Second language (ESL) 114G, the FIRST semester you are in residence. The AEOCPT test is scheduled for August and January. When the schedule has been announced, you will be notified by the department of the date of your test. Depending on your score, you may be required to take additional English coursework.

For more information about the AEOCPT test, please visit
https://aplng.la.psu.edu/programs/about-the-aeocpt

****Note: The Qualifying Examination includes additional evaluation of language proficiency by ESM faculty. A student's language proficiency (written and spoken) must be considered proficient to pass the examination.****

Chapter 12: Student Organizations

Opportunities for students to participate in social, student government, and professional organizations abound. Within the department, the student branches of SES (Society of Engineering Science) and SAMPE (Society for the Advancement of Materials and Process Engineering) are active. SES is especially interested in interdisciplinary endeavors.

SAMPE has been formed for the purpose of advancing and disseminating scientific, engineering, and technical knowledge, particularly with respect to the manufacturing and processing of materials. Announcements regarding SES and SAMPE's guest speakers and other activities are routinely distributed to Engineering Science and Mechanics students.

The ESM Graduate Council elects its officers annually. The Council advises the Head of the ESM department on issues affecting graduate students and their studies. From 2005, it also organizes ESM Today, an annual research symposium for ESM students.

Student concerns and issues may be addressed through the departmental student representative(s) of the Graduate Student Association or Engineering Graduate Student Council. The Engineering Graduate Student Council actively participates in the annual College of Engineering Open House which is open to high school students and their families.

Chapter 13: Sources of Information

Selected sources of information for graduate students include:

1. The Graduate Degree Programs Bulletin
   http://bulletins.psu.edu/bulletins/whitebook/index.cfm
2. Graduate School Thesis Guide http://www.gradsch.psu.edu/current/thesis.html
3. Schedule of Classes http://schedule.psu.edu/
4. Graduate Student Association http://www.gradsch.psu.edu/current/gsa.html
5. International Ministries http://www.impsu.org/
6. Guide to Graduate Life (published by the Graduate Student Association)
   http://www.pennstategsa.com/guide-to-graduate-life.html
7. International Hospitality Council and the International Student Council (for international students)
   http://www.global.psu.edu/students/involvement.cfm

Chapter 14: Important Deadlines for Fall and Spring

Deadlines by Semester	Fall 24	Spring 25	Summer 25
Apply to Graduate in LionPath	9/10	01/27	06/20
Submit doctoral presentation for format review	10/1	02/3	06/13
Submit master's thesis for format review	10/1	02/3	06/13
Pass doctoral defense	10/8	02/21	06/23
Submit final thesis or dissertation and supporting materials	11/1	03/24	07/7
Committee members to approve final thesis/dissertation	11/8	03/31	07/14

Questions graduate students frequently ask

What courses should choose?

Talk to your research adviser, follow recommendations for specific degree (tables 2.1-2.8)

What if my adviser is not from ESM?

Find a co-adviser affiliated with the ESM department (list of all eligible faculty is on department's website

When to schedule comprehensive?

When you complete all your courses;

– if scheduled for summer it needs to be completed before first day of classes,

- you need to be registered for the semester you have your comp (so for summer the best is to register for EMCH/ESC 600 for 1 credit)

While on RA – does 12 credits requirement include research credits or just courses?

Both may be used to reach 12

Are there any limits for GRE?

No GRE required at the moment, no cut off score

What are research credits courses?

12 credits for PhD; 6 for MS; only 6 letter grades allowed, the remaining must be awarded 'R'

*Post -comprehensive students should be registered for EMCH/ESC 601 at zero credits. If you have not passed your comprehensive, you should be registered for EMCH/ESC 600 NOT 601. *you should NEVER schedule an EMCH/ESC 600 or 601 course that does not have a faculty member listed or has staff listed as the instructor. If you do not see your research advisor listed for any section of EMCH/ESC 600 or 601, please contact Tammy Coval and she will have them added to a section so you are able to register for the course you need.*

Deadlines for scheduling final defense, intent to graduate, submission of written thesis, ..etc.

please check on grad school website since these dates differ from year to year : http://gradschool.psu.edu/completing-your-degree/thesis-and-dissertation-information/thesis-dissertation-performance-and-oral-presentation-deadlines-calendar/

What to do if I haven't completed SARI

Requirements for SARI https://www.research.psu.edu/training/sari *consist of: CITI online, plus ORP workshops https://www.research.psu.edu/orp (2hr) plus ESC 514 or ESC 515 (ethics discussion parts) – 3 hr.*

Taking ESC 515 for the whole semester will satisfy all SARI requieremtns.

Workshops are offered throughout the year and you may find some that are suitable for you. To make up 3 hr of in-person discussion you may find more workshops through different departments at PSU or/and ORP.

NOTE: it is the student's responsibility to meet all SARI requirements. Failure to do so will result in a delay of graduation until all credit hours are satisfied.

MS defense

schedule defense, notify Ashley about the date and time, follow recommended format (non-technical abstract as appendix) and be aware of deadlines

Ph.D. **and** MS?

"I was wondering what do I need to do in order to get a Master's degree? I am currently in Ph.D. program; however, I have already completed required course work to pursue a Master's Degree including graduate seminars. I heard that I can get both Master and Ph.D. degrees since I started directly Ph.D. without having a master".

Yes, after your MS degree is awarded, you will be considered a PhD student who enters the program with MS. It means that you will need to satisfy all course degree requirements – Table 3.2B, therefore it means more time spent in the program.

To initiate your MS while being on a PhD track you need to apply for 'Change of Degree' through the Grad School portal.

"Do I need to write a thesis, or could I count one of my first author published paper, which would be different than my Ph.D. main work?"

It depends what MS track you choose -for a non-thesis one your scholarly paper will be enough, for a thesis option you will need to write one.

IUG:

"I don't have any Graduate class that am going to take since I still need to take their prerequisite and the double counted course I choose is only offered in spring. Do I leave the course section of the semester report blank or I have to take some course count towards IUG program each semester?"

Since the double counted courses require two at the 400 level, take these.

What if I do not graduate (B.S.) in time?

Due to extenuating circumstances – Grad Officer may write a memo to grad school asking for extension

For the 2023/2024 academic year (graduating with a B.S. Spring 2024), is my starting semester of my MS Degree Summer of 2023 or fall of 2023?

While the MS portion starts in the Fall 2024, you will be starting the program (IUG) Fall 2023

The program name: I have it filled in at Engineering Science and Mechanics. Is that correct?

yes

Transcripts: I am just double checking that I DO NOT need an official transcript from Penn State to apply for the IUG program?

The transcripts are being pulled out for PSU students so you don't need to officially request them

How can I tell if I am graduating with an honors degree?

It will be determined at the time of your graduation (spring 2023), depending on your GPA (has to be 3.3 or better) and it will be stated on your diploma

I was told that I do not need to take the GRE to apply for this program. Do I just leave the test scores section blank?

Yes

Can my references be the same professors that I have asked to write my letters of recommendation or must they be different?

Yes, but one needs to be your senior (and then M.S.) research advisor

What are the advantages and disadvantages of waving or not my right my right for the release of information from my educational record?

Most students wave it – it makes the recommendation letters more meaningful

In work experience, If I am currently working somewhere how do I denote this in the application

state the dates…from….to present (employment category)

I am very confused at what both of the program specific questions mean and could use clarification on both of their meanings.

Answer no to stay in ESMCH

Choose a proper track (non-thesis or thesis)

APPENDIX A: Written Communication Rubric for Masters Degrees (M.S. Engineering Science and Mechanics, M.S. Engineering at the Nanoscale. M. Eng. in Mechanics)

To be Completed by the Research Adviser after the Oral Presentation of the Thesis

Candidate: _____

Date:_____

Adviser _____

	Excellent	Very Good	Satisfactory	Unsatisfactory
Context and Purpose for Writing the Thesis or Scholarly Paper *Circle one of the four boxes →*	Demonstrates a thorough understanding of context, audience and central purpose (hypothesis, design) of the document.	Demonstrates adequate understanding of context, audience. The central purpose (hypothesis, design,) is clearly defined.	Demonstrates awareness of context, audience and purpose. The central purpose (hypothesis, design,) is clearly defined.	Demonstrates minimal consideration of context, audience, purpose.
Document Organization *Circle one of the four boxes →*	Demonstrates detailed attention to and successful execution of important conventions that are appropriate to the writing tasks of the engineering and science disciplines for basic organization, content and presentation.	Demonstrates consistent use of important conventions that are appropriate to the writing tasks of the engineering and science disciplines for basic organization, content and presentation.	Follows expectations appropriate to the writing tasks of the engineering and science disciplines for basic organization, content and presentation.	No Attempt to use a consistent system for basic organization and presentation.
Technical and Scientific Content *Circle one of the four boxes →*	Uses appropriate, relevant and compelling content to illustrate a mastery of the subject throughout the document.	Uses appropriate and relevant content to illustrate a reasonable command of the subject.	Uses appropriate and relevant content to explore ideas through a preponderance of the work.	Does not use relevant content to develop and explore technological and scientific concepts.

Sources and Evidence *Circle one of the four boxes →*	Demonstrates skillful use of relevant and high-quality sources to support ideas that are appropriate for the discipline and genre (thesis or scholarly paper) of the writing.	Demonstrates consistent use of relevant and high-quality sources to support ideas that are appropriate for the discipline and genre (thesis or scholarly paper) of the writing.	Demonstrates an attempt to use credible and/or relevant sources to support ideas that are appropriate for the discipline and genre (thesis or scholarly paper) of the writing.	Does not demonstrate usage of relevant sources from literature.
Control of Syntax and Grammar *Circle one of the four boxes →*	Uses straightforward language that generally conveys meaning to readers. The language in the document has few errors.	Uses language that generally conveys meaning to readers with clarity, although writing may include some errors.	Uses language that sometimes impedes meaning because of errors in grammar.	Uses language with serious grammatical errors that limits the communication of technical and scientific concepts.

Total Assessment (circle one) = Excellent, Very Good, Satisfactory, Unsatisfactory

Written Comments by the Adviser:

Adviser Signature _____ Student Signature _____

APPENDIX X: QUALIFYING EXAMINATION REQUEST FORM

PennState
College of Engineering

ENGINEERING SCIENCE
AND MECHANICS

ESM Qualifying Examination Request Form *

_____ _____

Student's Name: PSU ID #

_____ _____ _____

Date of the Exam Location of the Exam Time of the Exam

Student: _____ _____

Signature Date

Adviser: _____ _____

Signature Date

I agree to serve as chair/committee member for the student and date specified on this form.

Chair of Committee: _____ _____ _____

Typed Name Signature Date

Member of Committee: _____ _____ _____

Typed Name Signature Date

Member of Committee: _____ _____ _____

Typed Name Signature Date

General areas of examination:

General Sources: [e.g. textbooks, papers, up to 7]

Specific area of examination:

Specific Sources: [generally 4-7]

Exam modality: (circle one) **Research proposal** **Literature Review**

Statement of the literature review/proposal and statement of expectations

APPENDIX X1 QERF - Research Proposal (Example)

PennState
College of Engineering

ENGINEERING SCIENCE
AND MECHANICS

Qualifying Examination Request Form

Constance Tipper	123 45 6789
Student's Name:	PSU ID #

30 March 1912	216 EES	12:00PM (noon)
Date of the Exam	Location of the Exam	Time of the Exam

Constance Tipper	15 March 1912
Student Signature	Date

Cliff Lissenden		15 March 1912
Student's Adviser	Adviser's Signature	Date

I agree to serve as chair/committee member for the student and date specified on this form.

Chair of Committee:	Christian Peco		
	Typed Name	Signature	Date
Member of Committee:	Parisa Shokouhi		
	Typed Name	Signature	Date
Member of Committee:	Christopher Kube		
	Typed Name	Signature	Date

General areas of examination:
Elasticity
Mechanical Behavior of Materials
Elastic Wave Propagation
Boundary Value Problems

General Sources*:* [e.g. textbooks, papers, up to 7]

M.H. Sadd, *Elasticity: Theory, Applications, and Numerics*.
N.E. Dowling, *Mechanical Behavior of Materials*.
J.L. Rose, *Guided Waves in Solid Media*.
R. Haberman, *Elementary Applied Partial Differential Equations*.

Specific area of examination*:*

Connecting ultrasonic nonlinearity with material nonlinearity through the material structure

Specific Sources*: [generally 4-7]*

- A. Hikata, et al., 1965, Dislocation contribution to the second harmonic generation of ultrasonic waves, *J. Appl. Phys*. 36(1):229-236.
- K.H. Matlack, 2015, Review of second harmonic generation measurement techniques for material state determination in metals, *J. Nondestr Eval* 34(1):273.
- K.-Y. Jhang et al., 2020, *Measurement of Nonlinear Ultrasonic Characteristics*, Springer, chapters 1-3.
- J.H. Cantrell, 2004, Fundamentals and applications of nonlinear ultrasonic nondestructive evaluation, in: *Ultrasonic Nondestructive Evaluation: Engineering and Biological Material Characterization*, T. Kundu Ed., CRC Press, pp. 363-433.

Exam modality*:* (circle one) (Research proposal) Literature Review

Statement of the literature review/proposal and statement of expectations

Write a proposal whose research objective is to connect the amplitude of second harmonic ultrasonic waves to the dislocation structure that develops in a metal as plastic deformation grows due to mechanical loading. The proposal is expected to include the following elements:

1. A succinct description of the primary mechanism responsible for plastic deformation in polycrystalline metal alloys;
2. An overview of the mathematical model for second harmonic generation of elastic waves;
3. A description of the experimental methodology used to measure second harmonic generation;
4. An outline of the proposed approach to connect second harmonic generation with quantifiable material structure characteristics.

While each of these four elements must appear in the proposal, their union is not the complete proposal; you are to follow the prescribed format in GPG section 3.1.7.

APPENDIX X2 QERF – Literature Review (Example)

PennState College of Engineering

ENGINEERING SCIENCE AND MECHANICS

Qualifying Examination Request Form

Isaac Newton	123 45 6789
Student's Name:	PSU ID #

30 March 1727	216 EES	12:00PM (noon)
Date of the Exam	Location of the Exam	Time of the Exam

J. Newton	30 February 1727
Student Signature	Date

Francesco Costanzo		30 February 1727
Student's Adviser	Adviser's Signature	Date

Qualifying Examination Committee

I agree to serve as chair/committee member for the student and date specified on this form.

Chair of Committee:	Reginal F. Hamilton		02/28/1727
	Typed Name	Signature	Date
Member of Committee:	Christian Peco		02/29/1727
	Typed Name	Signature	Date
Member of Committee:	Sulin Zhang		02/29/1727
	Typed Name	Signature	Date

General areas of examination:

Continuum Mechanics
Theory of Elasticity
Computational Method

General Sources: [e.g. textbooks, papers, up to 7]

R. M. Bowen, Introduction to Continuum Mechanics for Engineers, Plenum Press, New York, 1989.
Timoshenko, S. P., and J. N. Goodier, *Theory of Elasticity*, 3rd Edition, McGraw-Hill, New York, 1970.
Gilat, A. and Subramaniam, V., *Numerical Methods for Engineers and Scientists: An Introduction with Applications Using MATLAB*, 3rd Ed., John Wiley & Sons, Inc., Hoboken, 2014.

Specific area of examination*:*

Modeling of Soft Tissue

Specific Sources: [generally 4-7]

- M. Destrade, G. Saccomandi, and I. Sgura, Methodical fitting for mathematical models of rubber-like materials, *Proceedings of The Royal Society A-Mathematical Physical and Engineering Sciences*, 473 (2017), pp. 20160811–1–20160811–22. DOI: 10.1098/rspa.2016.0811.
- T. C. Gasser, R. W. Ogden, and G. A. Holzapfel, Hyperelastic modelling of arterial layers with distributed collagen fibre orientations, *Journal of The Royal Society Interface*, 3 (2006), pp. 15–35. DOI: 10.1098/rsif.2005.0073; PMID: 16849214; PMCID: PMC1618483.
- G. A. Holzapfel, T. C. Gasser, and R. W. Ogden, A new constitutive framework for arterial wall mechanics and a comparative study of material models, *Journal of Elasticity*, 61 (2000), pp. 1–48. DOI: 10.1023/A:1010835316564.
- G. A. Holzapfel and R. W. Ogden, Constitutive modelling of arteries, *Proceedings of The Royal Society A-Mathematical Physical and Engineering Sciences*, 466 (2010), pp. 1551–1596. DOI: 10.1098/rspa.2010.0058.

Exam modality*:* (circle one) Research proposal Literature Review

Statement of the literature review/proposal and statement of expectations

Arterial tissue is often modeled as a *hyperelastic* soft material. Earlier in the form, specific bibliographic references are indicated that represent important papers in the field of arterial modeling. These papers deal with both modeling issues as well as issues pertaining to the models' experimental characterization. Provided that you are not limited to reviewing the papers indicated, to the best of your abilities, review the given specific sources treating them as though they represented the current state of the art in the field. Then write a review of these papers identifying their main contributions. In your written review, be sure to define the various terms that appear in your mathematical description of the models. Furthermore, address questions of how such models can be used in a numerical setting as well as how such models can be characterized through experiments.

It is expected that you will present models not only in plain English, but also using equations. In presenting equations, be sure to define the various mathematical objects that appear in them. Predictive physical models are built on fundamental elements such as kinematics, balance laws, and constitutive equations. As appropriate, be sure to reflect this understanding in your written document.

You can make use of figures and tables from bibliographic sources provided that you explicitly identity said sources conforming to the professional standards used in scientific peer-reviewed publications.

APPENDIX Z: QUALIFYING EXAM Evaluation Forms

Engineering Science and Mechanics (ESM) Qualifying Exam Evaluation

Candidate: _____ Date:-
_____

Subject Title (from written and presentation documents): _____

Adviser: _____

Examining Committee Members:

(1)
(Chair)_____
_____

(2)
_____
_____

(3)
_____
_____

The Qualifying Exam provides an **early assessment** of the Program Learning Objectives as well as English Competency.

The form should be completed by the chair of the QEC and sent to the Graduate Program Head within two business days after the exam.

Program Learning Objectives Assessment

	Excellent	**Very Good**	**Satisfactory**	**Unsatisfactory**
Candidates will demonstrate an in-depth knowledge of the core theories and methods within the scope of topics and materials specified by the advisor and approved by the graduate program. The core demonstration will include the application of relevant mathematical, scientific, and engineering principles to the chosen field of study.				
Knowledge: *Circle one of the four boxes →*	The student demonstrates an excellent command of the subject matter that forms the basis for an advanced degree in ESM.	The student shows a very good command of the subject matter that forms the basis for an advanced degree in ESM.	The student is proficient in the subject matter that forms the basis for an advanced degree in ESM.	The student is seriously deficient in the subject matter that forms the basis for an advanced degree in ESM.

Candidates will be able to critically analyze work by others in their field of specialty.				
Critical Thinking: *Circle one of the four boxes →*	The literature was critically reviewed and the student demonstrated an excellent understanding of current state of the research topic.	The literature was critically reviewed and the student demonstrated a very good understanding of current state of the research topic.	The literature was reviewed and the student demonstrated an understanding of current state of the research topic.	The literature was not adequately reviewed and the student had a lack of understanding of the current state of the research topic.
Candidates will demonstrate the capacity to synthesize existing theory, models, and experiments to generate new concepts, designs, or hypotheses in ESM.				
Creativity: *Circle one of the four boxes →*	The research paper provides a nuanced and in-depth discussion of current knowledge gaps and displays creativity in describing research needed to substantially address them.	The research paper provides a very good discussion of major knowledge gaps and identifies the methods and research needed to address one or more of the key gaps.	The research paper is satisfactory. It summarizes the main knowledge gaps and outlines research that contributes to filling them.	The research paper's identification of knowledge gaps is lacking in depth and completeness; it displays an underdeveloped sense of how to organize research to address them.
Candidates will demonstrate the capacity to apply existing knowledge to address current problems in the multi-disciplinary field of ESM.				
Application: *Circle one of the four boxes →*	The research paper sets forth applications that not only expand upon those currently available, but that indicate a high degree of originality in advancing the state of the art.	The research paper sets forth applications that expand upon those currently available with a scope appropriate for doctoral research.	The research paper suggests applications that incrementally expand upon those currently available, but that in some way are limited in scope, flawed, or incompletely realized.	The research paper simply describes applications from the literature or suggests applications unlikely to be viable or to produce results.
Candidates will be able to convey ideas or arguments in clear, concise, well-organized papers as well as in formal, oral presentations.				
Communication: *Circle one of the four boxes →*	The student is able to defend their ideas coherently using fundamental principles and methods from their research topic, and they display a nuanced understanding of how the research topic is situated more generally in their field of study.	The student is able to defend their ideas coherently using fundamental principles and methods from their research topic area,	The student is, for the most part, able to defend their ideas, but they at times struggle to create coherent arguments and/or apply fundamental principles and methods from their research topic area.	The student is not able to defend their ideas coherently using fundamental principles and methods from their research topic

The committee's assessment of the Exam (Circle One): **Pass** **Fail**

* Students fail the QE if one or more of the subcategories of the PLO rubric is rated unsatisfactory. Each individual rating is established by majority vote.

Summary assessment statement, including identified deficiencies and recommendations for any remedial steps for the student to undertake (for example additional coursework and self-study). These recommendations will be followed up by the thesis committee at comprehensive exam. and remediation.

English Competency Assessment

	Excellent	Very Good	Satisfactory	Unsatisfactory
Use of Oral English *Circle one of the four boxes →*	The student demonstrates and excellent command of spoken English. They speak fluently, have a strong vocabulary, and are easily understood.	The student demonstrates a very good command of spoken English They can be clearly understood.	The student demonstrates a satisfactory command of spoken English. They can be understood, although with occasional lapses.	The student's ability to communicate by speaking is seriously impaired.
Use of Written English *Circle one of the four boxes →*	The style, grammar, word choice, and structure of the document are excellent. Use of language conveys meaning to the readers with a high degree of clarity and readability.	The style, grammar, word choice, and structure of the document are very good. The use of language facilitates understanding. The document is clear and well organized. .	The style, grammar, word choice and structure are good but with occasional lapses (e.g. poor word choices, grammatical errors). The document is readable, but the organization and clarity could be improved.	The use of English and/or organization of the document is sufficiently poor to make the text difficult to understand.

The QEC assessment of English Competency: ☐ **Competent** ☐ **Requires Improvement**

Suggestions for continued improvement or remediation:

Examining Committee Chair Signature _____

Graduate Program Head Signature _____

The results of the exam and the summary assessment will be provided to the student and their adviser by the Graduate Program Head within seven business days of the QE.

This publication is available in alternative media on request.

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