UNIVERSITY of PENNSYLVANIA

Ph.D. PROGRAM

GUIDELINES FOR GRADUATE STUDY

September 2014

Mechanical Engineering and Applied Mechanics
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1. INTRODUCTION

This document, also available at www.me.upenn.edu/current-students/doctoral/pdf/phd-handbook.pdf, describes the guidelines for the Ph.D. program in Mechanical Engineering and Applied Mechanics (MEAM). Additional information is available on the School of Engineering and Applied Science (SEAS) website: www.seas.upenn.edu/graduate/handbook. It is the student's responsibility to be familiar with the rules, procedures, and requirements of MEAM, SEAS, and the University of Pennsylvania. Advice and additional information may be obtained from your advisor, the Graduate Program Coordinator,[1] or the Graduate Group Chair.[2]

Students who matriculated before September 2014 are subject to the policies that were in effect as of their matriculation date.

2. ADMINISTRATIVE STRUCTURE

The graduate program in MEAM is administered by the MEAM Graduate Group. The MEAM Graduate Group is comprised of the primary faculty members of MEAM as well as faculty from other departments and schools throughout the University. This unique composition gives students the opportunity to work in emerging and interdisciplinary areas that are relevant to mechanical engineering. The current members of the MEAM Graduate Group and their research areas are listed in Appendix E. Additional information can be obtained from the website www.me.upenn.edu/about-research/research-matrix.php.

All graduate programs in SEAS fall administratively under the auspices of the Associate Dean for Graduate Education[3], whose activities with respect to graduate studies in MEAM are in conjunction with the recommendations of the MEAM Graduate Group Chair.

3. ADVISORS

An advisor is appointed for each Ph.D. student by the Graduate Group Chair. The advisor works with the student to develop an appropriate program of study and is responsible for monitoring the student's course plan and dissertation work.

4. GENERAL INFORMATION

The objective of the doctoral program is to educate a cadre of highly competent researchers who will pursue careers in academia, research, and technological leadership. The centerpiece of the doctoral program is dissertation research. Ph.D. students are expected to spend most of their time and energy generating high quality, original research. The courses taken during a student's tenure at the University will be geared mostly towards providing the necessary background to conduct quality research and to strengthen your knowledge. Each student's professional reputation and, to some extent, that of the department, depend on success in generating a high quality dissertation. Furthermore, the research grants that faculty receive and all other funding available in the department for graduate students are closely tied to the department's research productivity.

Course Selection Approval

Graduate students in MEAM have a wide variety of interests, and the MEAM graduate program is designed to encourage these interests. Some students prefer to take technical courses primarily within the Department; others desire to take a number of courses in other engineering or science departments. The student must obtain his/her advisor's approval for any course selection. A sample list of courses usually taken by MEAM doctoral students is available in Appendix A.

Typical Course Load

All students enrolled in a degree program are required to be continuously registered. Four courses per semester (including independent study or dissertation research courses) is considered to be a normal, full-time load for all doctoral students. Students must consult with the Graduate Group Chair if a deviation from the normal load is contemplated. Part-time students usually take one or, at most, two courses per semester.

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Registration, Leave of Absence

Continuous registration is required for all graduate students unless a formal leave of absence is granted by the Dean of the student's school. A student who has reached dissertation tuition status will not be granted a leave of absence, except for military duty, medical reasons, or in cases where the student receives a grant for dissertation research conducted abroad and the grant does not include funds to pay home institutional fees. A student not in dissertation status who desires a leave of absence must submit a request to the Graduate Group Chair and to the Graduate Division Office.

Changes in Course Program

Students may add or drop courses without penalty in any semester if it is done by the deadline listed in the current graduate bulletin. The student must inform the advisor of the decision beforehand and receive his/her approval. However, international students must maintain full time status in accordance with the rules administered by the Office of International Programs.

Grades, Credits, and Academic Standing

The grading system is as follows: A (4.0), Excellent; B (3.0), Good; C (2.0), Fair; D (1.0), Below Average; F (0.0), Failure; and (I) Incomplete. A course in which an F was obtained must be taken again; however, the F remains on the student's record. Courses for which a passing grade was obtained cannot be taken again for credit.

Doctoral students in the School of Engineering and Applied Science are expected to maintain at least a B average (3.0) in their work. A student whose record falls below a minimum of a B average will be put on academic probation and may be required to withdraw; graduation requires a minimum of a B average. Requirements cannot be satisfied by auditing courses or receiving an incomplete (I) grade.

Academic Integrity

Each MEAM student is expected to abide by Penn's Code of Academic Integrity (https://provost.upenn.edu/policies/pennbook/2014/02/13/code-of-academic-integrity). Students should not knowingly use any dishonest method to gain an unfair advantage over other students in academic pursuits, especially through, but not limited to:

- Giving or receiving any unauthorized aid on an assignment or exam, including working in groups on any assignment that has been designated as individual by the professor;
- Misrepresenting the originality of one's work (plagiarism), particularly through direct copying of work and also through failing to note the contributions of others, except as permitted by the instructor;
- Submitting substantially the same work for credit in more than one class, except with prior approval of the instructor.

If there is any doubt as to what is permissible, it is the student's responsibility to ask the instructor. Students caught cheating will be subject to disciplinary action, which may include referral to 36*1.08the Office of Student Conduct. For more information, please see the Student Guide on Academic Integrity: http://www.upenn.edu/academicintegrity/

5. DEGREE REQUIREMENTS

Detailed regulations and requirements concerning the degree are described in the current Graduate Student Handbook (www.seas.upenn.edu/graduate/handbook/index.php). It is the responsibility of the Ph.D. student to become familiar with all of the degree requirements in addition to those discussed in this document.

The Ph.D. requirements include the completion of graduate level work beyond the undergraduate degree with a grade-point average of at least 3.0 at the end of every semester, satisfactory performance in the Ph.D. qualifying and dissertation proposal exams, presentation of a departmental seminar, completion of three course units of teaching practicum, and the submission and successful defense of an original and significant dissertation. Students not making satisfactory academic progress may receive a warning or be placed on probation. In the absence of improvement in the subsequent semester, students on warning or probation may be dropped from their program. Each course is worth 1 course unit, with the exception of research (MEAM 999) and independent study (MEAM 899) courses, which can range from 1 to 4 course units on approval of the advisor. The milestones in the Ph.D. program are noted in Appendix B and described in detail in this document.

Core Requirements

Each doctoral student is required to take the following:

- The following two mathematics courses:
  - Principles and Techniques of Applied Math I (ENM 520)*
  - Principles and Techniques of Applied Math II (ENM 521)
- The following three core MEAM courses:
  - Continuum Mechanics (MEAM 530)
  - Advanced Dynamics (MEAM 535)
  - Transport Processes I (MEAM 570)
- At least one graduate course in MEAM beyond the core MEAM courses (depth requirement)
- At least one graduate course outside MEAM and not including ENM 520 or ENM 521 that is related to the student's research (breadth requirement)
- At least three additional graduate courses that are related to the student's research
- Three semesters of Teaching Practicum (MEAM 895; normally taken in 3rd, 4th and 5th semesters)
- Six semesters of the MEAM seminar (MEAM 699)
- Responsible Conduct of Research in Engineering (EAS 900; mandatory in the first year)

Notes:

- MEAM 530, 535, and 570 should be taken during the first three years of the Ph.D. program.
- Neither MEAM 899 (Independent study) nor MEAM 999 (Research) can be used to satisfy the above core requirements.
- Students should check their preparedness for ENM 520 by reviewing the syllabus before registering for the course. If this material is unfamiliar, the student should take ENM 510 prior to taking ENM 520.

6. POLICY ON TRANSFER OF CREDIT UNITS EARNED AT OTHER INSTITUTIONS

A maximum of nine graduate-level course units taken at another university may be accepted provided that the grade received in each course was at least a B. This is subject to approval by the Graduate Group Chair and the Associate Dean for Academic Affairs in accordance with the rules of the University at the time of matriculation. The student who wishes such credit transfer must petition to the Graduate Group Chair and enclose with the petition the documents and information stated below and in Appendix D. In order to obtain credit for courses taken at other institutions the following steps must be taken:

- For each transfer course, obtain the course description and the title of the textbook prescribed for the course.
- Identify a professor who teaches a similar course at Penn. If a similar course is not offered at Penn, identify a professor whose areas of expertise are in the general area of the course to be transferred. The professor should certify that the course is of similar level to a graduate course offered at Penn or, if a similar course is not offered at Penn, that the course qualifies for Penn students to take if it were offered here.
- Submit a petition on a standard form (Appendix D) to the Graduate Group Chair. Attach to the petition a copy of the transcript, the professor's certification, and documents and information noted in Appendix D.

7. INDEPENDENT STUDY

Independent study courses are important vehicles to accommodate special interests of the students that are not served through the regular courses. They create opportunities for mini-projects and a mentoring relationship between students and faculty. Independent study also can serve as a means for students and faculty to lay a potential foundation for dissertation work prior to making a long-term commitment. The student should identify the topic and scope of the independent study in the semester prior to the one in which s/he intends to take on the independent study, and should identify a faculty advisor whose interests and expertise match the independent study topic.

Since independent studies are less structured than regular courses and typically do not come with strict deadlines, occasionally students tend to fall behind in their work. There is also the possibility of miscommunication between the

student and the faculty on the objectives, extent, scope, and the grading method for the independent study.

The purpose of this policy is to set the rules for an independent study with the objectives of maintaining academic rigor and minimizing any potential for a miscommunication.

- An independent study course should require an effort comparable to that of a regular course, about 10 hours a week or a total of 126 hours per semester.
- The student should meet the faculty member administering the independent study (the advisor) on a regular basis, at least once a week. It is the student's responsibility to schedule these weekly meetings. Past experience indicates that failure to maintain regular contact with the student's advisor can lead to a less than satisfactory performance in the independent study course. The key to a successful independent study is a steady effort throughout the semester. The student should not expect to be able to cram a semester's work into a few days of intensive work at the end of the semester.
- Prior to the beginning of the semester in which the student contemplates taking the independent study, the student and his/her advisor should develop an independent study proposal. The first paragraph of the proposal should describe the objectives, scope, and content of the independent study. The second paragraph should state how the independent study will be evaluated and how the student will be graded. The document should be signed by both the student and his/her advisor, and it should be submitted to the Graduate Group Chair for approval before the beginning of the semester.
- At the conclusion of the independent study, the student should prepare a brief report specifying what material was covered during the independent study, which objectives were met, and which were not. In the event that objectives were not met, a clear explanation should be provided as to why such objectives were not met. This document should also be signed by the student and his/her advisor, and it will be included in the student's file.
- It is the student's responsibility to make sure that these guidelines are followed. Failure to follow these guidelines may result in the student’s not receiving credit for the independent study.

8. TEACHING PRACTICUM

Participation of graduate students in the teaching mission of the department helps to develop teaching, presentation, leadership, and interpersonal skills while assisting the department in discharging its teaching responsibilities. All doctoral students are required to complete three semesters of teaching practicum (MEAM 895). MEAM 895 is an 0.5 course unit class that requires the equivalent of 10 hours of effort per week for one semester. In fulfillment of the teaching practicum requirement, students will perform several of the following duties under faculty guidance, as appropriate: attend seminars on teaching and communication skills, lead recitations, lead tutorials, supervise laboratory experiments, develop instructional laboratories, develop instructional materials, and grade homeworks, laboratory reports, and exams. A teaching training seminar is conducted during the first month of the fall semester. Attendance is mandatory for all second year students. To the extent possible, students will participate in a broad range of teaching activities beyond grading. Some of the recitations will be supervised, and feedback and comments will be provided to the student by the faculty responsible for the course. At the completion of 0.5 course unit of teaching practicum, the student will receive a Satisfactory/Unsatisfactory grade and a written evaluation signed by the faculty member responsible for the course. The evaluation will be based on comments of the students taking the course and the impressions of the faculty in charge. International students whose first language is not English are required to take and pass the SPEAK test, which assesses English proficiency. SPEAK must be taken in April of the student’s first year.

It is an unfortunate fact that cheating occasionally occurs in classes taught at Penn. Teaching assistants are often the first to notice questionable behavior among students that might be construed as cheating. It is the responsibility of the teaching assistant to understand what is permissible and what is considered cheating for each of their three teaching practicum classes.

Teaching assistants who see what appears to be cheating in progress, for example during an exam, should take the following steps:

- Interrupt the impermissible conduct and immediately and quietly remove or confiscate notes or other materials a student is using. It is important that the notes be saved as potential evidence
- Ask that students move apart/change seats
- Reiterate the expectations and rules on examination-taking for the class
- Permit a student to complete an examination, even if cheating is suspected
- After the exam is over, set the completed examinations aside and record names of nearby students, in case it is

necessary to contact witnesses at a later time
- Tell the faculty member in charge of the class about the suspected cheating incident

Teaching assistants who suspect cheating after the fact, for example identical homeworks submitted by two or more students, should consult with the faculty member in charge of the class.

Helpful information on how to discourage cheating may be found in the Faculty Guidelines for Academic Integrity: www.upenn.edu/osc/pages/faculty.html.

9. OBSOLETENESS

The Ph.D. program, culminating in a successful defense of the doctorial dissertation, must be completed within a period of 10 years from the year of matriculation as a graduate student in the School of Engineering and Applied Science of the University of Pennsylvania.

10. THE MEAM Ph.D. QUALIFYING EXAMINATION POLICY

All students who are working towards the Ph.D. degree must take and pass the Ph.D. Qualifying Examination. This examination serves to determine a student's ability to independently conduct research of high quality. M.S.E. students who think that they may wish to continue on for the Ph.D. in MEAM may also petition the Graduate Group Chair and request to take this exam.

The qualifying examination is administered in the following manner:

1. By the end of his/her first semester, each full-time doctoral student will elect an independent study in the general area in which s/he wishes to pursue dissertation research. The independent study will be carried out during the second semester, and it will be mentored by a willing faculty advisor chosen by the student. The advisor must be a member of the MEAM Graduate Group. While the advisor need not be the student's Ph.D. dissertation advisor, students are advised to choose faculty advisors who are likely to serve as their dissertation supervisor in the future.

2. The independent study course taken for the qualifying exam will follow the basic guidelines outlined in Section 7, with the additional condition that the independent study be research oriented. A research oriented independent study can consist of a critical review of a body of literature, a new contribution to address gaps in the existing literature, a formulation and possibly a solution of a new mathematical model, an experimental study, or a combination of the above. The independent study should afford the student the opportunity to carry out independent research.

3. Before the end of his/her first semester, the student will submit an independent study proposal to the Graduate Coordinator, who will convey it to the Graduate Group Chair. The independent study proposal should be brief (no more than two pages in length) and must be signed by the student and the advisor. It should be written in a way that is comprehensible to individuals other than the student and his/her advisor. The first paragraph of the proposal should state the scope and objectives of the study. The scope should be consistent with at least ten hours of work per week for the duration of the semester. The second paragraph should state how the objectives will be achieved. The third paragraph should state how the independent study will be evaluated and how the student will be graded. The fourth paragraph should state the deliverables at the end of the study. A list of pertinent references should be provided at the end of the proposal.

4. At the beginning of the second semester, the Graduate Group Chair will appoint a Qualifying Examination Committee for each student. The Committee will include the student's advisor, a committee chair, and a math examiner. The math examiner's responsibility is to ensure that the student has a fair knowledge of undergraduate mathematics as contained in the syllabi of MATH 104, 114, 240, 241 and ENM 251. The student is also expected to know the concepts taught in all the graduate math courses (such as ENM 510, 520, 521) taken before the qualifying exam. At least half of the committee members, including the committee chair, must be members of the MEAM Graduate Group. The Committee will be chosen based on the area of the student's independent study. If desired, the student may choose to make a mid-semester brief oral presentation to the Committee to obtain feedback on research progress.

5. By the date of the last final examination of his/her second semester, the student will submit a hard copy report to his/her Qualifying Exam Committee that summarizes his/her independent study work. The title page of this report

should include the independent study title, student's name, name and roles of all committee members, and the time, date, and location of the Qualifying Exam. The student will also submit an electronic version of the report to the Graduate Coordinator, who will convey it to the Graduate Group Chair. The cover page of the report must indicate the date, time, and location of the qualifying exam. The paper should be written in the format of a journal paper, and it should be understandable by an educated audience not expert in the field. The due date of the papers will not be extended. The student will receive a grade for the independent study given by the faculty advisor. This grade will be independent of the outcome of the qualification process.

6. No later than a month after the last day of finals, the student will take the oral portion of the qualifying examination. Only students in good academic standing will be allowed to take the examination. "Good academic standing" implies that the student has a minimum grade point average of 3.0 at the time of the examination. In the examination, the student will present his/her paper to the Committee and respond to questions. The Committee may ask additional questions related more broadly to the independent study and on material covered in the student's courses (including mathematics courses). The math examiner (and any other committee members) may ask questions on mathematics relevant to the broad area of the independent study.

7. The Qualifying Exam Committee will review the student's record in coursework, his/her performance in the independent study, and his/her performance in the oral examination. Then, the committee chair, in consultation with other members of the committee, will make a recommendation to the Graduate Group Chair on the outcome of the qualifying examination. The Committee may also suggest a course plan or make other recommendations to help the student deal with any weaknesses in his/her background. In exceptional cases, the Committee may recommend the submission of a revised paper and/or another presentation. The deadline for this revised paper/presentation will be determined by the Graduate Group Chair in consultation with the Committee. The Graduate Group will make the final decision as to whether the student passes the exam. The Graduate Group Chair will inform the student about the result and if applicable, will specify the deadline for any revised papers, presentations or other recommendations. Part-time students must take the Qualifying Exam after they have completed six courses, at the first time it is offered. If the deadlines stated here are not adhered to, an explanatory letter signed by the student and the advisor must be submitted to the Graduate Group Chair for approval.

8. The qualifying examination must be completed no later than two months after the last day of final examinations in the spring semester.

9. It is the student's responsibility to notify/remind his/her committee members of the time and place of the Qualifying Exam. Scheduling the date/time for the qualifying exams will be coordinated by the student. The student will inform the Graduate Coordinator of the date/time of the exam and s/he will coordinate the location and inform the student.

11. THE DIRECT PATH TO THE Ph.D. FOR STUDENTS WITHOUT AN M.S.E. DEGREE

Students who have only a bachelor's degree and wish to study for the Ph.D. are encouraged to register as Ph.D. students. However, they may obtain a Master's degree if they so desire during their Ph.D. program. The students must inform the Graduate Group Chair, in writing of their intent with respect to the Master's degree.

12. OBTAINING AN M.S.E. DEGREE

The master and doctoral programs have different objectives. An M.S.E. degree will not be automatically granted to a Ph.D. student upon the completion of 10 course units. Doctoral students who desire to obtain an M.S.E. degree at some point along their doctoral studies must petition the Graduate Group. The Graduate Group or its designee will review the petitioner's records and determine whether the granting of the M.S.E. degree is appropriate. Typically, M.S.E. degrees are awarded to Ph.D. students at the end of their third year at Penn.

13. DISSERTATION

Several recognized paths are available to the student when choosing a dissertation topic. Often the topic will be the natural result of sponsored research the student may be working on. Sometimes a particularly challenging problem at the student's place of employment will form the foundation for a dissertation. Regardless of the route by which a dissertation topic is chosen, a student must have a faculty member willing, by mutual agreement, to act as a dissertation advisor. It is essential that the student realize that the dissertation is the culmination of years of study and is the distinguishing feature of the Ph.D. degree. Clearly, dissertation topics and advisors should be chosen with care and deliberation. The student

should feel free to discuss possible topics and dissertation supervision with any and all MEAM faculty members.

MEAM 999 is the course number assigned to dissertation research. Several units of this course may be taken simultaneously. The grading of MEAM 999 is done by the student's dissertation advisor. Only grades of "S" (satisfactory), "U" (unsatisfactory) or "I" (incomplete) can be earned in this course.

Each Ph.D. student is required to have a Dissertation Committee in place by the end of their second year of study. The role of the Committee is to provide guidance and feedback to the student throughout their doctoral program. The Dissertation Committee is distinct from the Qualifying Exam Committee, whose purpose is to examine the student's readiness for Ph.D. research. The Dissertation Committee must be composed of at least three members, including the advisor and the Committee Chair. The Committee Chair must be a member of the MEAM Graduate Group and cannot be the student's advisor. Additional committee members may come from disciplines related to the student's research topic. The Committee may include members who are not on the faculty of the University of Pennsylvania, subject to approval by the Graduate Group Chair, as long as at least three members of the Committee are faculty of the University of Pennsylvania. At least half of the Committee members must be members of the MEAM Graduate Group.

The following steps are required to appoint a Dissertation Committee:

- The Ph.D. student and the advisor discuss and agree upon which faculty would be suitable Committee members
- The Ph.D. student contacts each prospective Committee member to determine whether they would be willing to serve on the Committee
- Once all Committee members have agreed, the Ph.D. student e-mails the Graduate Group Chair (copying the advisor and the Graduate Program Coordinator) to request formal appointment of the selected faculty members to the Committee
- If the Graduate Group Chair approves, the Committee will be appointed. The student and Committee will be notified upon approval. If approval is not granted, the Graduate Group chair will work with the advisor and student to appoint an appropriate committee

Changes in a Ph.D. student's Dissertation Committee membership may sometimes be warranted, for example due to a change in the student's research direction, faculty sabbatical leave, or other occurrence. In such instances, the student should contact the Graduate Group Chair (copying the advisor and the Graduate Program Coordinator) to request approval of any proposed changes to the Committee.

A full-time Ph.D. student must prepare and present his/her dissertation proposal to the Dissertation Committee by the end of the third year of study. No dissertation proposal may be presented without prior approval of the Dissertation Committee by the Graduate Group Chair. At least two weeks before the dissertation proposal presentation, the student will submit a hard copy of the proposal to his/her Dissertation Committee. The student will also submit an electronic version of the proposal to the Graduate Coordinator, who will convey it to the Graduate Group Chair. The cover page of the proposal must indicate the date, time, and location of the dissertation proposal presentation. Any extensions to the proposal deadline must be approved by the Graduate Group Chair. At the dissertation proposal meeting, the candidate will present the proposed research topic, scope, and method of research, and partial results (if any). This preliminary meeting is intended to be helpful in discussing the student's planned program, scope of work, and method of approach, and in providing proper guidance. The committee often makes constructive suggestions for strengthening the research and the eventual dissertation. The Dissertation Committee Chair will inform the Graduate Group Chair and the student, in writing, on whether the Dissertation Committee has approved the proposal and what its recommendations are on further work. If the proposal is not approved by the Dissertation Committee, the student must make the necessary improvements, resubmit, present the new proposal, and earn its approval. The proposal must be completed at least six to twelve months prior to the final dissertation defense. A Ph.D. student is advanced to Ph.D. candidacy after successfully presenting the dissertation proposal.

To avoid any misunderstanding, it is emphasized that the dissertation itself is not approved at the dissertation proposal meeting; only the area of the research topic and a general plan of the dissertation are approved. Furthermore, the advisor and the student may ask the committee to reconvene at other times if they feel that there is further benefit to be gained from discussing the research topic. The student is also encouraged to consult frequently with the Dissertation Committee members and to inform them of his/her progress.

Any significant changes to the proposed research after the proposal must be presented to and approved by the Committee.

When the dissertation advisor is satisfied with the dissertation presented to him/her by the student, copies of the dissertation are given to the members of the Dissertation Committee for study and critique. Normally, the Dissertation Committee members require three or four weeks to examine a dissertation, and the student should recognize this when attempting to meet deadlines. Once all members of the Committee are satisfied with the dissertation, the student may then schedule the dissertation defense. If the Committee feels that major modifications are in order, the defense cannot be scheduled until such modifications are made to the Committee's satisfaction.

The dissertation defense by the doctoral candidate is given at a meeting open to the public. The announcement of the defense to the public must be submitted to the Graduate Coordinator for posting at least three weeks prior to the presentation. After the presentation by the candidate, the Dissertation Committee will question him/her on several aspects of the work. Additional questions or comments from others attending the presentation will then be solicited. The general public will then be asked to leave the room prior to a final session at which more questions may be asked by the Dissertation Committee. The Dissertation Committee will decide on acceptance or the non-acceptance of the dissertation at the conclusion of this meeting.

Once the dissertation has been accepted by the Dissertation Committee, the student will submit the final version of the thesis with the advisor's signature for the approval of the Graduate Group Chair. The student will submit the thesis to the Graduate Group Chair at least two weeks prior to the university's deadline for Ph.D. theses. After examining the thesis, the Graduate Group Chair may either approve and sign the thesis or return the thesis to the student requesting additional modifications.

It is noted and emphasized that the dissertation must be prepared and submitted in accordance with the rules and schedules of the School of Engineering and Applied Science of the University of Pennsylvania. The format is explained in the booklet "Doctoral Dissertation Manual" available at: https://provost.upenn.edu/uploads/media_items/dissertation-manual.original.pdf. In addition to the two unbound copies of the dissertation and other items, which need to be submitted to the Office of the Associate Dean for Graduate Education and Research, two or more hardbound copies must be submitted to the Graduate Group Chair and advisor(s) as stated in Appendix C. Failure to follow the above schedule and requirements will result in a delay in awarding the degree.

All dissertations must be freely publishable and the contents cannot be restricted from dissemination to the community at large by the candidate's place of employment or the sponsoring agency, the government, or any person. Any computer source code which constitutes a portion of the thesis (with the exception of readily-available commercial software) must be available to the community at large. It is the responsibility of the student to ensure that the above requirements are duly considered in the planning and execution of the research program and in the presentation of the final document.

14. SEMINAR PRESENTATION REQUIREMENT

As a part of their degree requirements, all doctoral students must present a departmental seminar on their research prior to their dissertation presentation. This seminar must be given at least one semester before the anticipated graduation date.

The Ph.D. seminar requirement serves the following purposes:

- The seminar gives the student an opportunity to practice presenting technical material and "think on his/her feet" while responding to questions from the audience. Similar seminars are often required by prospective employers both in academia and industry as a part of the interviewing process.
- The seminars help inform other students and faculty about ongoing research. These should be of particular interest to first year graduate students who are trying to identify relevant research areas.
- The seminars may help foster intellectual interactions in the department and the formation of a scholarly community. Comments and questions during the presentation may provide constructive suggestions to the presenter regarding how to improve his/her thesis while there is still time to do so.
- The presenters may include in their CV the fact that they have given a seminar at Penn.

No Ph.D. student will be able to graduate without fulfilling the Ph.D. seminar requirement. Ph.D. seminars are scheduled during the summer at the usual MEAM seminar time and receive public notice similar to that of other departmental seminars. It is the responsibility of the student to schedule a date for his/her seminar with the Graduate Coordinator for a time when his/her advisor and preferably the entire Dissertation Committee is available. Students should be aware that the seminar calendar is typically finalized before the beginning of each semester. Ph.D. students who wish to give a talk

during any given summer will need to fix the date at least a month prior to the beginning of the semester. Typically, the seminar should be presented no later than the end of the fourth year after matriculation.

The presenter should prepare his/her seminar carefully, keeping in mind that he/she is going to talk to an intelligent audience with diverse backgrounds, some of whom may not be familiar with the speaker's specific research area. The student should have his/her advisor(s) critique the visuals and the presentation before the public presentation. A good introduction which gives background information, context, and motivation is a good idea. To allow ample time for discussion, the talk should not exceed 40 minutes. The presenter should anticipate and be ready to answer questions from the audience. During the discussion period, in order to encourage student questions, students in the audience will have be given a chance to ask questions before the faculty members do so. After the presentation, the student's adviser provides the student with feedback including comments on both strengths and areas for possible improvement. The presentation may be videotaped to give the student an opportunity to see himself/herself the same way the audience have seen him/her.

15. ATTENDANCE AT DEPARTMENTAL SEMINARS AND THESIS PRESENTATIONS

The attendance of all full-time graduate students at departmental seminars is mandatory. There are many good reasons why students should attend departmental seminars even when the seminars are not directly linked to their area of research. For example:

- The seminar provides an opportunity to learn about the state-of-the-art in Mechanical Engineering and Applied Mechanics.
- The seminar provides an opportunity for the student to get acquainted with people from other institutions and companies and get a birds-eye view of the culture at other institutions. On more than one occasion, during job interviews, interviewers have been known to mention a visit to Penn and delivering a seminar. The student would like to be in a position to comment on that particular seminar and state how enjoyable it was.
- The departmental seminars are one of the few opportunities there are to get together as a department. It is hoped that a full attendance at these seminars will help create departmental spirit and cohesiveness.

Seminar course

The seminar course has been established so that students get recognition for their seminar attendance as well as to encourage students to attend. There will be no quizzes, tests, or homeworks. The course will be graded S/U. In order to obtain a satisfactory (S) grade, the student will need to attend more than 70% of the departmental seminars. For example, in a term in which 12 seminars are given, the student will need to attend at least 9 seminars to obtain a satisfactory grade. Participation in the seminar course will be documented and recorded in the student's transcript. In order to obtain their degree, doctoral candidates will be required to accumulate 6 seminar courses. Under special circumstances, i.e., in a case of a conflict with a course, the student may waive the seminar requirement for a particular semester by petition to the Graduate Chair. Part-time students are exempted from the seminar attendance requirement although they are encouraged to attend the seminars.

16. SUMMER STUDIES

There are several possibilities for scholarly activities by graduate students at the University during the summer which include:

- Independent study and research (MEAM 899 or 999) with an instructor willing to act as a supervisor during the summer.
- Course work outside SEAS, as well as a limited number of regular courses occasionally offered by some SEAS departments. The advisor, in consultation with the Graduate Group Chair, must approve summer school courses.

Full-time students supported by research grants are expected to be in residence for the summer. Students who wish to take summer courses must obtain approval from their faculty advisor prior to registration. Questions on summer session registration should be referred to the Graduate Coordinator.

17. RECORDS

The official graduate student records are kept in 111 Towne Building and transcripts can be viewed on PennInTouch at https://medley.isc-seo.upenn.edu/penn_portal/intouch/splash.html. Graduate students are encouraged to periodically check the accuracy of their records and to bring any discrepancies to the attention of the Graduate Group Chair.

18. FINANCIAL SUPPORT

Financial support for graduate students is made available through a number of sources such as funds from SEAS, funds from MEAM, research grants of the faculty, and industrial sources, where research support is predominant among all. A given faculty member plays the primary role in selecting a student for a research fellowship supported by his/her grant. Appropriate committees will choose students for other scholarships and internal fellowships. The Graduate Group Chair formally makes all fellowship appointments. Most sources of funding, research grants in particular, include support for the summer months. Students are expected to work full time on research in the summer months during which they are supported.

19. THE GRADUATE ENVIRONMENT

The size of the Department of Mechanical Engineering and Applied Mechanics fosters a close interaction between the graduate students and the entire faculty. This enhances the quality of student-faculty communications and enriches the academic environment to benefit both learning and discovery.

Apart from offering advising, seminars and meetings to introduce incoming students to faculty research, and informal meetings with the Department Chair and Graduate Group Chair to solicit student input and exchange information, the Department strongly supports the Mechanical Engineering Graduate Association (MEGA). MEGA is a student-run association that represents the entire graduate student community in MEAM, and organizes both social and technical events. A chosen representative of MEGA will be invited, if appropriate, to attend Graduate Group meetings to serve as a communication channel for information between the Graduate Group and students.

Every effort is made to create an environment of scholarship, creativity and learning, which is the very essence of graduate study.

APPENDIX A

A Sample Ph.D. Program in Mechanical Engineering & Applied Mechanics

Thermo/Fluids	Mechanics of Materials	Mechanical Systems	Bio mechanics
1st Year - Fall			
ENM 520- Principles and Techniques of Applied Mathematics I (R)			
MEAM 530 Continuum Mechanics (R)	**MEAM 530 Continuum Mechanics (R)**	**MEAM 535 Advanced Dynamics (R)**	MEAM 555 Membranes and Polymers in Biology (E)
MEAM 570 Introduction to Transport Phenomena (R)	MEAM 519 Introduction to Elasticity (E)	MEAM 520 Intro to Robotics(E) or ESE 500 Linear Systems Theory (E) or ESE 504 Introduction to Optimization Theory (E)	**MEAM 570 Introduction to Transport Phenomena (R)** or MEAM 554 Mechanics of Materials (E)
MEAM elective or MEAM 899 Independent Study (E)			
EAS 900 Responsible Conduct of Research in Engineering (R)			
MEAM 699 Departmental Seminars (R)			
1st Year - Spring			
ENM 521- Principles and Techniques of Applied Mathematics II (R)			
MEAM 527 – Finite Element Analysis (E)	MEAM 527 – Finite Element Analysis (E)	MEAM 513 Linear Control Systems (E)	MEAM 527 – Finite Element Analysis (E)
MEAM 571 – Advanced Transport (E) or MEAM 642 Advanced Fluid Mechanics (E)	MEAM 632 – Plasticity (E)	MEAM 527 Finite Element Analysis (E)	Graduate Course in the Bio-Sciences
MEAM 899 Independent Study (R)			
MEAM 699 Departmental Seminars (R)			

E → elective
R → required

A Sample Ph.D. Program in Mechanical Engineering & Applied Mechanics (continued)

Thermo/Fluids	Mechanics of Materials	Mechanical Systems	Bio mechanics
2nd Year – Fall			
MEAM 535 Advanced Dynamics (R)	**MEAM 535 Advanced Dynamics (R)**	**MEAM 570 Introduction to Transport Phenomena (R)**	**MEAM 535 Advanced Dynamics (R)**
MEAM 575 Micro and Nano Fluidics (E) or MEAM 647 Fundamentals of Complex Fluids (E)	**MEAM 570 Introduction to Transport Phenomena (R)**	**MEAM 530 Continuum Mechanics (R)**	**MEAM 530 Continuum Mechanics (R)**
MEAM 999 (2 units) Thesis Research			
MEAM 895 Teaching Practicum (R)			
MEAM 699 Departmental Seminars (R)			
2nd Year - Spring			
ENM 601 Mathematics (R)			
MEAM 571 Advanced Topics in Transport Phen. (E) or 642 Fluid Mechanics I (E)	MEAM 635 – Composite Materials (E)	MEAM 527 Finite Element Analysis (E)	Graduate Course in the Bio-Sciences
MEAM 999 (2 units) Thesis Research			
MEAM 895 Teaching Practicum (R)			
MEAM 699 Departmental Seminars (R)			

A Sample Ph.D. Program in Mechanical Engineering & Applied Mechanics (continued)

Thermo/Fluids	Mechanics of Materials	Mechanical Systems	Bio mechanics
3rd Year - Fall			
MEAM 575 Micro and Nano Fluidics (E) or MEAM 572 Micro/Nano Energy Transport (E)	MEAM 633 Fracture Mechanics (E)	MEAM 613 Nonlinear Control Theory (E)	Graduate Course in the Bio-Sciences (E)
MEAM 999 (3 units) Thesis Research			
MEAM 895 Teaching Practicum (R)			
MEAM 699 Departmental Seminars (R)			
3rd Year Spring			
MEAM 561 Thermodynamics (E)	MSE 660 Atomistic Modeling (E)	MEAM 635 Composite Materials (E)	Graduate Course in the Bio-Sciences (E)
MEAM 999 (3 units) Thesis Research			
MEAM 699 Departmental Seminars (R)			

APPENDIX B

Time Line for Ph.D. Students

By the End of Semester	Objectives
1	Define an Independent Study Course
2	Submit A Paper Summarizing The Independent Study By The Last Day Of Finals
2+one month	Make An Oral Presentation of The Independent Study Paper
2	Register for First Teaching Practicum
3	Select a Dissertation Committee
3	Register for Second Teaching Practicum
4	Present and Obtain Approval for a Thesis Proposal
4	Register for Third Teaching Practicum
8	Present a Departmental Seminar
	Submit a Dissertation Draft to your Advisor
	Submit a Revised Dissertation Draft to Your Dissertation Committee
	Obtain Committee's Approval to Schedule Dissertation Defense
TD-3weeks	Publicize Dissertation Defense
TD	Defend Dissertation
	Make Corrections and Modifications to Dissertation
GD-4 weeks	Submit a Copy of the Dissertation to the Graduate Group Chair for Approval
GD	Submit Final Dissertation to the Graduate School
GD	Graduate

TD → thesis-defense date
GD → graduation date

APPENDIX C

Hard Cover Instructions for Ph.D. Thesis

Guidelines:

In addition to the unbound copies that must be given to the School of Arts and Sciences, one hardbound copy of each Ph.D. thesis must be submitted to the Graduate Group Chair and one hardbound copy must be submitted to each of the student's advisor.

There is a charge of $25.00 per copy. Please check with the Graduate Program Coordinator for more information about hard binding your thesis or dissertation.

Ph.D. dissertations are to be bound in a black cover with gold letters.

The lettering on the front should look like the following example:

Alfred E. Neuman

Design Optimization and Control of a Multi-robot System to Study the Size-Dependent Effects in the Mechanics of Muscle Cells Flowing Through Heated Micro Conduits

Ph.D. Dissertation
Mechanical Engineering and Applied Mechanics
University of Pennsylvania
2014

APPENDIX D

GRADUATE TRANSFER OF CREDIT PETITION

FROM:_____ _____
Name of Student PENN ID #:

DEPT/MAJOR: _____

DATE: _____

Include with this petition, course numbers and descriptions from the appropriate bulletin listing and a final transcript. A maximum of **two** courses may be transferred to the Master's program or a maximum of **nine** to the Ph.D. program if approved. Courses counted towards an undergraduate degree will not be considered for graduate credit unless in an approved submatriculation program.

TRANSFER OF CREDIT TO: ☐ Master's program ☐ Ph.D. program

FROM WHICH UNIVERSITY: _____

Please list courses to be transferred and SEAS equivalent if applicable:

	COURSE	SEAS EQUIVALENT	# CUS
1)			
2)			
3)			
4)			
5)			
6)			
7)			
8)			
9)			

_____
Adviser's Approval Date

_____
Graduate Group Chair Date

☐ Approved ☐ Disapproved

_____
Deputy Dean for Education Date

APPENDIX E

MEAM Graduate Group Members

Allen, Mark (mallen@seas.upenn.edu), Alfred Fitler Moore Professor, ESE, and Scientific Director, Singh Center for Nanotechnology.

Paulo E. Arratia (parratia@seas.upenn.edu), Associate Professor. Micro- and nano-fluidics, complex fluids, hydrodynamic instabilities, swimming & locomotion, rheology, and soft-condensed matter.

P. S. Ayyaswamy (ayya@seas.upenn.edu), Asa Whitney Professor of Dynamical Engineering. Phase change heat and mass transfer processes, bioheat/mass transfer: gas embolism, targeted drug delivery, and arc-plasma heat transfer.

Igor Bargatin (bargatin@seas.upenn.edu), Class of 1965 Term Assistant Professor. Micro/nanoelectromechanical systems (MEMS/NEMS). Micro-and nano-scale energy transducers, such as thermionic energy converters and thermal light sources. Composite materials with ultra-low work functions.

John L. Bassani (bassani@seas.upenn.edu), Richard H. and S. L. Gabel Professor of Mechanical Engineering. Plastic deformation of crystals, atomic/continuum property relationships, interface mechanics, fracture mechanics, material stability at large strains, adhesion, mechanics of living cells.

Haim H. Bau (bau@seas.upenn.edu), Professor. Micro and nano fluidics, nanotechnology, real time electron microscope imaging of processes in liquids, lab on chip technology, diagnostic devices for point of care, electrokinetics, electrochemical energy storage, and fluid and particle motion under the actions of electric and magnetic fields.

Robert W. Carpick (carpick@seas.upenn.edu), John Henry Towne Professor and Chair. Nanotribology (contact, friction, adhesion, lubrication, wear), experimental nanomechanics, surface science and engineering, and thin films. Development, characterization, and applications of materials and devices at the nanoscale including micro/nanoelectromechanical systems (MEMS/NEMS). Development and application of advanced scanning probe microscopy tools.

Dennis E. Discher (discher@seas.upenn.edu), Robert D. Bent Professor, Chemical and Biomolecular Engineering. Stem cell mechanics, single molecule mechanics, statistical mechanics of networks and complex fluids.

David M. Eckmann (David.Eckmann@uphs.upenn.edu), Horatio C. Wood Professor of Anesthesiology & Critical Care. Experimental and computational biofluid dynamics, interfacial fluid mechanics, molecular mechanics of cellular activation and biological adhesion to vascular tissue, biomimetic materials and targeted drug delivery.

Dawn M. Elliott (delliott@udel.edu), Professor and Director, Biomedical Engineering, College of Engineering, University of Delaware. Orthopaedic biomechanics of the intervertebral disc; anisotropic, nonlinear, and viscoelastic biomechanics; models of disc degeneration; structure-function of the disc.

Daniel S. Gianola (gianola@seas.upenn.edu), Skirkanich Assistant Professor of Innovation, Materials Science and Engineering. Nano- and micromechanics of materials, atomic-scale deformation mechanisms, *in situ* testing using electron microscopy, strain engineering of transport phenomena for efficient energy conversion, materials under extreme environments.

Howard H. Hu (hhu@seas.upenn.edu), Professor. Numerical simulations of complex flows with multiphase and polymeric fluids, particulate flows, flows in microfluidic devices, electrokinetic phenomena, hydrodynamic interfacial instability.

Michelle Johnson (johnmic@mail.med.upenn.edu), Assistant Professor of Physical Medicine and Rehabilitation and Bioengineering. Physical Medicine and Rehabilitation Department.

Daniel E. Koditschek (kod@seas.upenn.edu), Alfred Fitler Moore Professor of Electrical and Systems Engineering. Robotics, computational neuromechanics, dynamical systems theory applied to design of intelligent machines and their control.

Katherine J. Kuchenbecker (kuchenbe@seas.upenn.edu), Associate Professor and Undergraduate Curriculum Chair. Haptics for teleoperation, virtual environments, and robotic manipulation, with application to medical simulation, robotic minimally invasive surgery, stroke rehabilitation, personal computing, and personal robotics.

Vijay Kumar (kumar@seas.upenn.edu), UPS Foundation Professor. Robotics, multi-vehicle control, dynamical systems, systems biology.

Noam Lior (lior@seas.upenn.edu), Professor. Heat transfer, fluid mechanics, thermodynamics, exergy analysis, with applications to energy conversion, advanced power generation and hybrid systems, global warming alleviation, solar energy, sustainable energy and water desalination development, sustainability science, combustion, water desalination, materials processing.

Jennifer R. Lukes (jrlukes@seas.upenn.edu), Associate Professor. Nanoscale thermal, fluid, and mass transport; molecular dynamics simulation; laser-based materials characterization; micro- and nanoscale engineering.

X. Sherry Liu (xiaoweiL@mail.med.upenn.edu), Assistant Professor of Orthopaedic Surgery and Bioengineering. Bone biomechanics, imaging and image analysis of biological tissues, metabolic bone diseases and treatments.

Irina Marinov (imarinov@sas.upenn.edu), Assistant Professor, Earth & Environmental Science and Long Term Guest Investigator, Woods Hole Oceanographic Institution.

Robert L. Mauck (lemauck@mail.med.upenn.edu), Associate Professor of Orthopaedic Surgery and Bioengineering. Biomechanics of tissue engineered musculoskeletal tissues, Bioreactor development for mechanical stimulation, Mechanobiology of cells and tissues, Fabrication and modeling of hydrogels and nanofibrous scaffolds.

George J. Pappas (pappasg@grasp.upenn.edu), Joseph Moore Professor of Electrical and Systems Engineering and Department Chair. Hybrid systems, hierarchical control systems, embedded systems, nonlinear systems, geometric control theory, robotics, unmanned aerial vehicles.

Pedro Ponte Castañeda (ponte@seas.upenn.edu), Raymond S. Markowitz Faculty Fellow and Professor. Nonlinear composite and polycrystalline materials, smart materials, microstructure evolution and localization in manufacturing processes, mechanics of polymers, fracture mechanics, nonlinear variational principles in mechanics.

Prashant Purohit (purohit@seas.upenn.edu), Associate Professor and Graduate Group Chair. Rod theories for DNA and biopolymers, mechanics of sub-cellular organelles, mechanics at the bio-nano interface, martensitic phase transitions in solids.

Celia Reina (creina@seas.upenn.edu), William K. Gemmill Term Assistant Professor. Multiscale modeling, finite plasticity, phase transformations, ductile failure.

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Talid R. Sinno (talid@seas.upenn.edu), Professor of Chemical and Biomolecular Engineering. Computational materials science, multiscale modeling and simulation, nucleation and aggregation phenomena in electronic materials and complex fluids.

Louis J. Soslowsky (soslowsk@upenn.edu), Fairhill Professor of Orthopaedic Surgery, Professor of Bioengineering and Director of McKay Orthopaedic Research Laboratory. Orthopaedic biomechanics and functional tissue engineering; structure-function studies of tendons and ligaments; models of tendon injury, repair, and healing; shoulder joint mechanics.

David J. Srolovitz (srol@seas.upenn.edu), Joseph Bordogna Professor of Engineering and Applied Science. Computational and theoretical materials science; defects, growth, evolution and deformation of materials.

Camillo J. Taylor (cjtaylor@central.cis.upenn.edu), Professor of Computer and Information Science. Reconstructing and rerendering 3D scenes from 2D images and vision guided robotic systems.

Kevin T. Turner (kturner@seas.upenn.edu), Gabel Family Term Associate Professor. Micro/nanoscale materials and manufacturing, experimental and computational fracture and contact mechanics, small-scale adhesion mechanics, micro/nanoelectromechanical systems, mechanics of biological interfaces and cells.

Karl T. Ulrich (ulrich@wharton.upenn.edu), Vice Dean of Innovation, CIBC Professor of Operations and Information Management (Wharton School). Product design, product development, innovation, technology development, personal transportation, environmental issues.

Vaclav Vitek (vitek@lrsm.upenn.edu), Harold Pender Professor of Materials Science and Engineering. Computer modeling of the structure and properties of grain boundaries, metal-metal and metal-ceramic interfaces, dislocations and other lattice defects.

Beth A. Winkelstein (winkelst@seas.upenn.edu), Associate Dean, Undergraduate Education and Professor of Bioengineering. Spine biomechanics; modeling & experimental methods in subfailure mechanics; joint & tissue mechanics; mechanical modulation of pain and cellular dysfunction; mechanotransduction in injury & repair.

Mark Yim (yim@grasp.cis.upenn.edu), Professor and Director of Integrated Product Design. Modular self-reconfigurable robotics, biologically inspired mechanisms, flying devices, self-assembling structures.