2020-2021

Engineering Mechanics Graduate Manual

Virginia Polytechnic Institute

& State University

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Engineering Mechanics Graduate Regulations Manual
Virginia Tech

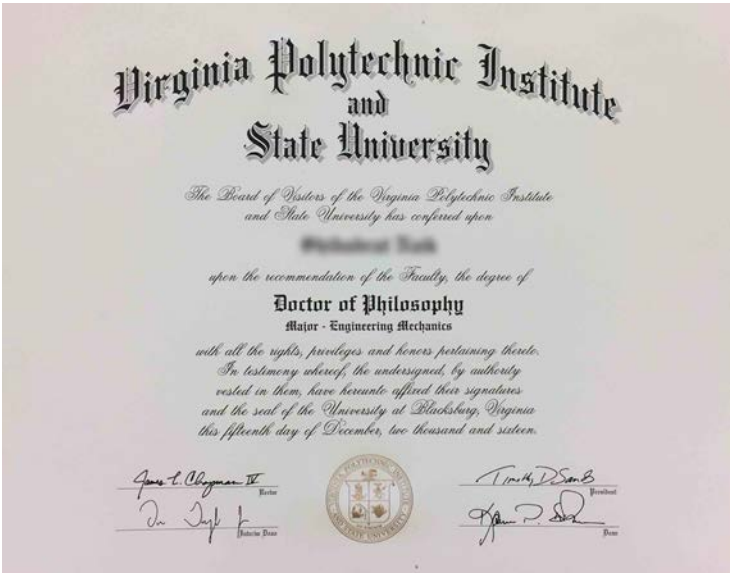
I. Introduction

This manual is a guide for students who are planning their graduate studies in Engineering Mechanics at Virginia Tech. This guide is intended to supplement, not to replace, the *Graduate Catalog* published by the Graduate School of Virginia Tech.

All references to credit hours in this manual are based on the semester system.

II. General Information

Administratively, the Engineering Mechanics Graduate Program (hereafter the "EM Program") is contained within the *Department of Biomedical Engineering and Mechanics* (BEAM) at Virginia Tech. Prior to 2014, the EM Program was administered by the *Department of Engineering Science and Mechanics* (ESM), and Virginia Tech offers an undergraduate minor in ESM. Informally, the graduate degrees and program are sometimes referred to as *ESM*, and all courses offered directly by the EM Program are labeled as "ESM XXXX". Academically, the EM Program involves faculty from multiple departments across different colleges at Virginia Tech, and a number of the ESM graduate courses are cross-listed with other graduate programs, making the EM Program a highly interdisciplinary collection of students and faculty. Regardless of an advising faculty member's primary academic department, all graduate degrees earned by students in the EM Program are designated as *Degrees in Engineering Mechanics*; see the example diploma to the right. The cover pages of theses and dissertations must state that the degree is in *Engineering Mechanics*.


Virginia Polytechnic Institute
and
State University

The Board of Visitors of the Virginia Polytechnic Institute and State University has conferred upon

[redacted]

upon the recommendation of the Faculty, the degree of

Doctor of Philosophy

Major - Engineering Mechanics

with all the rights, privileges and honors pertaining thereto. In testimony whereof, the undersigned, by authority vested in them, have hereunto affixed their signatures and the seal of the University at Blacksburg, Virginia this fifteenth day of December, two thousand and sixteen.

A. Graduate Student Orientation

Each fall, the EM Program conducts a mandatory orientation session for all graduate students. The orientation provides information on EM requirements, procedures for fulfilling those requirements, and other topics of importance to new students. Additional departmental and university training may be required.

B. Continuous Enrollment

Graduate students in the EM Program must be registered *continuously* at Virginia Tech during the academic year (fall and spring semesters) and pay the prescribed tuition and fees (or have these costs covered by an assistantship). Except for the options listed below, enrollment must be continuous from the time of first enrollment until earning a degree. Graduate students who need a break from continuous enrollment can do so by applying for a *leave of absence* or by participating in programs and activities approved by the Graduate School that require absence from

the University (*in absentia status*). Students who fail to follow this process will be resigned from the university by the Graduate School and will then need to apply for readmission in order to continue their studies. Readmission requires a positive recommendation from the EM Program and is not guaranteed.

C. Minimum Hours of Registration

Full-time enrollment for Virginia Tech graduate students, for purposes of tuition and fees, consists of a minimum of 9 credit hours during academic year (fall and spring) semesters. However, the Commonwealth of Virginia does not count students as full time unless they are enrolled for at least 12 credits. Students being supported on an assistantship, fellowship recipients, and scholarship recipients must therefore register for at least 12 credit hours each semester of the academic year.

The minimum enrollment requirement is 3 credit hours at Virginia Tech during each semester of the academic year, except in the case of a student who qualifies for a *Start of Semester Defense Exception* (see Section II. K).

Summer session enrollment is optional. Students should consult with their faculty advisor before registering for summer session courses. Students must be registered in order to schedule a Graduate School approved examination during the summer.

Enrollment credits may consist of any combination of course credits, dissertation credits (5994, 7994), independent study credits (5974, 6974), or special study credits (5984, 6984). Students registered for 5994 and 7994 are expected to devote time to research in proportion to the numbers of credit hours registered. Degree requirements for course enrollment are described in Section IV(for MS degrees) and Section V (for PhD degrees).

D. Residency Requirement

Students enrolled in the EM Program are expected to be residents of the Blacksburg area (or nearby areas such as Roanoke) so that they can participate regularly and consistently in the many academic, research, and professional development activities on the Blacksburg campus of Virginia Tech. Exceptions to this requirement must be approved by the student's faculty advisor and the GPD.

E. Academic Advising and Plan of Study

Students must select a faculty advisor (also known as the academic advisor, committee chair, chairperson, major professor, or faculty mentor), form an advisory committee, and complete a Plan of Study. Selecting an advisor and committee must be done with the consent of the faculty involved. The Plan of Study must be approved by the faculty advisor and the student's advisory committee before being submitted to the EM Program GPD and GC. Once a Plan of Study is approved by the EM Program, it is submitted by the GPD to the Graduate School for approval. Modifications to the Plan of Study, such as changing listed courses or changing advisory committee members, can be made by submitting the appropriate paperwork to the Graduate School: Change of Committee/Advisor form, Change in the Plan of Study form.

The Plan of Study must be submitted no later than the end of the 2nd semester of enrollment for MS students and by the end of the 3rd semester for PhD student. Failure to submit the Plan of Study in a timely fashion may result in a loss of credits and the inability to hold an assistantship. An approved Plan of Study must be on file with the Graduate School in order to schedule an exam requiring Graduate School approval (such as the Preliminary Exam).

F. Evaluation of Progress

The Graduate School requires that each department conduct an annual performance and progress evaluation for its graduate students. Each spring, EM students are required to submit a *Progress to Degree Report* to the department. Students will be evaluated on their academic and research progress using the contents of their progress report. The report must include an evaluation by their faculty advisor (see IIE). Both the faculty advisor and the student must sign the report prior to submission to the EM GC.

G. Academic Probation

Students whose cumulative GPA falls below a "B" (3.00 GPA) are placed on probation by the Graduate School. Enrollment for one semester while on academic probation is permitted to remedy an unsatisfactory GPA. If the student does not achieve a cumulative 3.0 GPA within one semester after being placed on probation, the student will be dismissed from the Graduate School.

If a student placed on academic probation does not achieve a cumulative 3.0 GPA within one semester, an appeal for additional time can be submitted by the GPD to the Graduate School. In order for an appeal to be submitted, the student must work with their faculty advisor to develop a remediation plan that details steps to be taken to raise the student's GPA to 3.0 or higher, including (i) the courses to be taken, (ii) the corrective action(s) to be taken, and (iii) the amount of time requested for the extension. If the remediation plan is approved by the student, the faculty advisor, and the GPD, then an appeal (including the remediation plan) will be submitted to the Graduate School. If extra time is granted by the Graduate School, the student will be informed in writing of the amount of additional time allowed for achieving a 3.0 GPA. If the EM Program does not support a time extension, or if the extension request is denied by the Graduate School, the student will be dismissed from the Graduate School. If the student does receive a time extension, and then does not achieve a 3.0 GPA within the time specified by the Graduate School, the student will be dismissed from the Graduate School.

H. Scholarly Ethics and Integrity Requirement

All graduate students are expected to uphold the Virginia Tech Principles of Community and the Graduate School's Expectations for Graduate Education as well as the scholarly integrity and research ethics standards for engineering mechanics.

Students are expected to complete the requirements of the *Engineering Mechanics Scholarly Ethics and Integrity Plan* (see Appendix A) within 12 months of enrolling as a graduate student in engineering mechanics. Plans of Study will not be approved by the department until the program's *Scholarly Ethics and Integrity* requirements are completed.

Failure to complete the *Scholarly Ethics and Integrity* requirements within 12 months of enrollment will affect eligibility for financial support on assistantships and scholarship awards.

I. Diversity & Inclusion Requirement

In April 2018, The Commission on Graduate Studies and Policies (CGS&P) approved a new requirement for graduate students: an inclusion and diversity component (CGS&P Resolution 2017-18A). This requirement aligns with the Graduate School's goal of providing all students with an affirming, inclusive, and diverse education program that helps prepare students to face the complex challenges they will meet in their post-graduation careers. Engineering Mechanics graduate students entering the program starting in 2019-20 satisfy this requirement by successfully completing *ENGE 5304: Graduate Student Success in Multicultural*

Environments (1 credit) within the first two semesters of enrollment. For additional information on this Graduate School requirement, see https://graduateschool.vt.edu/faculty-and-staff-resources/inclusion-diversity-requirement.html. This 1 credit course is not included on the Plan of Study.

J. Financial Support

There are two general categories of appointment for graduate students: Graduate Teaching Assistant (GTA) and Graduate Research Assistant (GRA). Both will be referred to as Graduate Assistants (GAs) unless specific information pertaining to one of them is involved. GAs must maintain an overall GPA of 3.00 or above.

Work periods for GAs are normally based on the following semester or summer session periods:

- Fall semester: August 10 to December 24
- Spring semester: December 25 to May 9
- Summer I: May 10 to June 24
- Summer II: June 25 to August 9

GAs are required to work between the dates stated on their appointment letter.

Students on a 100% assistantship are expected to work an average of 20 hours per week during the appointment period. For the fall and spring academic appointment periods, students are expected to perform 390 total hours of work (average of 20 hours per week for 19.5 weeks). For the summer sessions, students are expected to perform 130 total hours of work. Fractional appointments scale as expected. These hours can be distributed by the GA supervisor throughout the appointment period as needed to support the assigned research (GRA) or teaching (GTA) activities. Students cannot be required to work for more hours than designated by their appointment. Students are asked to report to the GPD or GC any discrepancies they experience between these expectations and the actual GA effort. Hours worked in support of a GRA appointment are in addition to time spent conducting research for 5994 and 7994 credit hours.

GAs will be evaluated continuously by the faculty member supervising their work and formally reviewed at the end of each semester. If their work is not satisfactory or if they are not making satisfactory progress towards their EM degree, their financial support may not be renewed, and in extreme cases may be discontinued.

Financial support may be extended on a semester-to-semester basis, within the guidelines of the Virginia Tech Graduate School and with the mutual agreement of the student, their faculty advisor, the GPD, and the BEAM department head. All GAs must sign an *Assistantship Agreement* form for the period of their appointment. Because GRA appointments are subject to the availability of external funding and GTA appointments are subject to the availability of university funding, the EM Program cannot guarantee the continuity of these appointments. GTAs are arranged on the student's behalf by their faculty advisor; students are not to request a GTA from the EM Program on their own.

K. Vacation Policy

Students appointed on any Graduate Assistantship (GTA or GRA) are considered employees of the Commonwealth of Virginia (COV). As such, Graduate Assistants (GAs) are given the same holidays as faculty. Human Resources has the current listing of these holidays (note that GAs do not receive the staff-only holidays). With the exception of these dates, GAs are expected to be working in support of assigned teaching or research duties for the full appointment period (see Section II. I). Approval for any additional vacation time must be preapproved by the faculty advisor (for GRAs) or the course supervisor (for GTAs). Note that class breaks (fall break, spring break, etc.) are not vacation days unless they correspond with official university holidays.

L. Start of Semester Defense Exception

Start of Semester Defense Exception (SSDE) is a special enrollment category that allows enrollment for one (1) credit if students have fulfilled all requirements, *including advisory committee review and agreement that the thesis or dissertation is ready to be defended*, and are registering only to take the final examination. To qualify for SSDE, students must meet all of the criteria established by the Graduate School and complete the Start of Semester Defense Exception Request.

M. Graduate Honor Code

The Graduate Honor Code establishes academic integrity among graduate students. All incoming graduate students are notified of the honor code upon application to Virginia Tech. By accepting admission, you agree to comply with the Graduate Honor Code, which requires honesty and ethical behavior in all academic pursuits. The Graduate Honor System (GHS) upholds and enforces the Graduate Honor Code. The GHS exists to educate students and faculty about the Graduate Honor Code, to investigate and hear all cases that are referred to the GHS, and to impose a penalty when a student is found guilty. You can find additional information about the GHS by reviewing the Constitution of the Graduate Honor System, which details GHS procedures, rights of accused students, and rights of referrers. The procedures in the Constitution are strictly adhered to in all GHS matters. The Constitution is found online in the Graduate Honor Code web site.

N. Student Health Care

All full-time graduate students are required to pay a health-service fee. The Schiffert Health Center provides limited medical care for all students when the university is in session and for those students who are required to work between terms. Schiffert lacks operating facilities, extensive equipment, and medical specialists. Thus, they provide services only for minor medical ailments and sicknesses. Persons are not eligible for health services when they are not registered. The fee does not provide health services for the student's family.

International students are required to have insurance on themselves and all family members. The insurance policy can be obtained through the university (information can be found here) or through private U.S. and foreign insurance companies. Students who maintain 50-100% assistantship appointments and who have purchased the university-sponsored health care plan are eligible to receive a contribution towards their health insurance premiums.

O. Language Requirement

University business and all instruction are conducted in English. There are a number of campus and community resources to help with English conversation skills. They include:

English practice groups through the Virginia Tech Writing Center
YMCA conversation groups

There is no foreign language requirement for the EM Program. However, foreign language requirements are optional at the discretion of the student's advisory committee. Any language courses taken do not count towards the required program hours on the Plan of Study.

P. Justification of Courses

Academic work, including transfer credit, must meet the time limits specified below. Requests for revalidation of out-of-date courses must be submitted by the student and include signatures of all members of the student's advisory committee and the GPD. Revalidations are normally for a period of one year unless otherwise noted.

Course work more than five years old at the time of submission of the Plan of Study must be revalidated to count toward the master's or doctorate by completing the Course Justification Request through the Graduate School.

Q. Transfer credit

In general, transfer credits are formally reviewed/approved at the time the Plan of Study is submitted. Credits may be transferred from a regionally accredited university. All such credits must have earned grades of "B" or better, have been earned while in good standing in graduate status, and must have been graduate courses at the institution where the student took the course. Grades of "S" or "P" are not acceptable for transfer credit. All transfer courses must be reviewed and acceptable to the student's Advisory Committee and the GPD. Official transcripts are required before transfer course work can be approved for the Plan of Study. Transferred courses count as credit hours but are not included in the calculation of the Virginia Tech GPA (i.e., the grade does not transfer). For transfer course work more than five years old, a Justification of "old" course work form must be filed with the Plan of Study.

Research, Project and Report, Practicum or Internship credit hours may not be transferred from another university to meet Virginia Tech graduate degree requirements (i.e., they cannot be included on the Plan of Study). Credits taken while in undergraduate status or for an undergraduate degree cannot be used as transfer credit for a graduate degree, with the exception of Virginia Tech students enrolled in the Accelerated Undergraduate/Graduate (UG/G) program who have received pre-approval for this credit through submission of the UG/G paperwork.

Transfer credit for any of the EM degree core courses (e.g., ESM 5014; see Section IV.B for MS degrees and Section V for PhD degrees) requires pre-approval by the GPD and the student's academic advisor. Please contact the GC for the pre-approval form. Submission of this form must be accompanied by detailed information from the course(s) taken at the other university, including required textbook details, a list of the assigned homework problem statements, and copies of the administered test questions (only the assignments/tests are needed, not the corresponding work). If transfer of any core courses is pre-approved, you can include those courses on your Plan of Study.

Transfer credit limits are described in Section IV (for MS degrees) and Section V (for PhD degrees).

III. Requirements for the Accelerated Undergraduate/Graduate (UG/G) Program

The EM Program invites applications to the Accelerated Undergraduate/Graduate (UG/G) Degree Program for highly qualified VT undergraduate students from any major. Students may apply for admission to an M.S. or Ph.D. degree as a part of this program. If admitted, they are then able to double-count up to 12 credit hours toward both their undergraduate and graduate degree programs. Application to this program is available to VT students who meet the following qualifications:

- Students must have an overall undergraduate GPA of 3.3 or higher; GRE scores are not required.
- Students must submit an application through the Graduate School. The degree admission term is for the first semester after the bachelor's degree is to be awarded. For example, if a student expects to finish the bachelor's degree in Spring 2021, they would apply for admission for Fall 2021. Double-counting of courses would begin in their senior year of undergraduate studies.

A. Double-Counting Courses

Acceptance into the program allows the student to 'double-count' up to 12 hours of coursework, which is chosen in advance and taken during the senior year. Six of the 12 hours can be at the 4000 level, with the other 6 hours being at the 5000 level. Courses included on a UG/G student's list of proposed coursework must be consistent with the course requirements for the appropriate graduate degree.

B. Application Instructions

The deadline for applying to the UG/G program is August 1. The student needs to confer with the Engineering Mechanics Graduate Coordinator as well as the undergraduate advisor in his/her 'home' undergraduate department in order to choose the courses that will be double-counted. Students should apply through the normal VT online application process. Students will choose either the M.S. or the Ph.D. degree in Engineering Mechanics and then indicate in the application that they are pursuing the UG/G (checkbox option after application is started), and the effective term will be the semester in which the student becomes a full-time graduate student (not the beginning term of the senior year). For more information from the Graduate School about the UG/G application process, visit the Graduate School Admissions.

IV. Requirements for the Engineering Mechanics Degrees of Master of Science and Master of Engineering

A. Degree Options

The Engineering Mechanics Program offers the Master of Science (MS, thesis and non-thesis) and Master of Engineering (MEng) degrees. Each degree requires completion† of a minimum of 30 credit hours with a minimum overall GPA of 3.0.

1. Master of Science (MS) thesis option

Students pursuing the MS thesis degree option must complete at least 30 credit hours, including at least 21 graded course credit hours (see Plan of Study below), and satisfactorily prepare and defend a master's thesis (see Final Examination below).

The final transcript will designate the degree as thesis.

2. Master of Science (MS) non-thesis option

Students pursuing the MS non-thesis degree option must complete at least 30 graded course credit hours (see Plan of Study below), and satisfactorily pass a comprehensive oral examination (see Final Examination below). This option must be declared at the time the Plan of Study is submitted to the Graduate School.

The final transcript will designate the degree as non-thesis.

3. Master of Engineering (MEng)

This program is oriented toward engineering practice instead of fundamental research, teaching or further study. (Recipients of this degree are not barred, however, from pursuing more advanced degrees.) This degree is intended to increase the competence of students who are interested in design, development, operation, and engineering practice.

Students pursuing the MEng degree option must complete at least 30 credit hours, including at least 27 graded course credit hours (see Plan of Study below), and satisfactorily prepare and defend an engineering project report (see Final Examination below). The purpose of the project report is to

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† In this document, "completing" a course includes the requirement that the resulting grade be a C– or better for graded courses, a P for pass/fail courses, or an EQ for research or project/report credits. This is to comply with a VT Graduate School requirement as listed in the Graduate Catalog: 'Courses on the Plan of Study with grades below "C-" must be repeated.'

develop and demonstrate the candidate's ability to plan and execute projects relating to the practice of engineering.

B. Plan of Study

The student's Plan of Study must include the courses described below.

1. Master of Science (MS) thesis option

The MS thesis option Plan of Study must include at least 30 credit hours that satisfy the following requirements:

- ESM 5994 Research and Thesis *(at least 6 credits)*
- ESM 5014 Introduction to Continuum Mechanics *(3 credits)*
- One ESM 5xxx/6xxx course in two of the following three areas: dynamics, solid mechanics, or fluid mechanics *(3 credits in each area, for a total of 6 credits)*; see the GC for a current list of approved courses
- One course satisfying the mathematics requirement *(3 credits)*; see the GC for a current list of approved courses
- Graded elective courses *(at least 9 credits)*

MS students must also satisfactorily complete *ENGE 5304: Graduate Student Success in Multicultural Environments* (*1 credit*) within the first two semesters of enrollment. This course satisfies the Graduate School's *Diversity and Inclusion Requirement* (see Section II.I.). This course credit is not included on the Plan of Study.

MS students must also register for one credit hour of 5944 Seminar for at least two semesters. These seminar credits are not included on the Plan of Study.

The MS Plan of Study may contain a combination of 5xxx and 6xxx-level courses and a maximum of six (6) hours of approved 4xxx-level courses (see the GC for a current list of approved 4xxx-level courses).

A minimum of 12 course credits must be labeled ESM (not including 5944 or 5994).

A maximum of six (6) credit hours of independent study (IS) or special study (SS) courses can be used to complete the Plan of Study, with the total for both IS and SS courses not exceeding six (6) hours.

The number of course credits transferred cannot exceed the number of course credits taken at Virginia Tech. Research, Project and Report, Practicum or Internship credit hours may not be transferred from another university to meet Virginia Tech graduate degree requirements (i.e., they cannot be included on the Plan of Study).

2. Master of Science (MS) non-thesis option

The MS non-thesis option Plan of Study must include at least 30 credit hours that satisfy the following requirements:

- ESM 5014 Introduction to Continuum Mechanics *(3 credits)*
- One ESM 5xxx/6xxx courses in two of the following areas: dynamics, solid mechanics, or fluid mechanics *(3 credits in each area, for a total of 6 credits)*; see the GC for a current list of approved courses
- One course satisfying the mathematics requirement *(3 credits)*; see the GC for a current list of approved courses
- Graded elective courses *(at least 18 credits)*

MS students must also satisfactorily complete *ENGE 5304: Graduate Student Success in Multicultural Environments* (*1 credit*) within the first two semesters of enrollment. This course satisfies the Graduate School's *Diversity and Inclusion Requirement* (see Section II.I.). This course credit is not included on the Plan of Study.

MS students must also register for one credit hour of 5944 Seminar for at least two semesters. These seminar credits are not included on the Plan of Study.

The MS Plan of Study may contain a combination of 5xxx and 6xxx-level courses and a maximum of six (6) hours of approved 4xxx-level courses (see the GC for a current list of approved 4xxx-level courses).

A minimum of 12 course credits must be labeled ESM (not including 5944 or 5994).

A maximum of nine (9) credit hours of independent study (IS) or special study (SS) courses can be used to complete the Plan of Study, with the total for both IS and SS courses not exceeding nine (9) hours.

The number of course credits transferred cannot exceed the number of course credits taken at Virginia Tech. Research, Project and Report, Practicum or Internship credit hours may not be transferred from another university to meet Virginia Tech graduate degree requirements (i.e., they cannot be included on the Plan of Study).

3. Master of Engineering (MEng) option

The MEng option Plan of Study must include at least 30 credit hours that satisfy the following requirements:

- ESM 5904 Project and Report *(3 credits)*
- ESM 5014 Introduction to Continuum Mechanics *(3 credits)*
- One ESM 5xxx/6xxx course in two of the following areas: dynamics, solid mechanics, or fluid mechanics *(3 credits in each area, for a total of 6 credits)*; see the GC for a current list of approved courses

- One course satisfying the mathematics requirement *(3 credits)*; see the GC for a current list of approved courses
- Graded elective courses *(at least 15 credits)*

MEng students must also satisfactorily complete *ENGE 5304: Graduate Student Success in Multicultural Environments* (*1 credit*) within the first two semesters of enrollment. This course satisfies the Graduate School's *Diversity and Inclusion Requirement* (see Section II.I.). This course credit is not included on the Plan of Study.

MEng students must also register for one credit hour of 5944 Seminar for at least two semesters. These seminar credits are not included on the Plan of Study.

The MEng Plan of Study may contain a combination of 5xxx and 6xxx-level courses and a maximum of six (6) hours of approved 4xxx-level courses (see the GC for a current list of approved 4xxx-level courses).

A minimum of 12 course credits must be labeled ESM (not including 5944 or 5994).

A maximum of six (6) credit hours of independent study (IS) or special study (SS) courses can be used to complete the Plan of Study, with the total for both IS and SS courses not exceeding six (6) hours.

The number of course credits transferred cannot exceed the number of course credits taken at Virginia Tech. Research, Project and Report, Practicum or Internship credit hours may not be transferred from another university to meet Virginia Tech graduate degree requirements (i.e., they cannot be included on the Plan of Study).

C. Advisory Committee

Each graduate student must have an advisory committee, which guides and approves the Plan of Study, evaluates the student's academic progress, advises the student on their research (when applicable), and conducts the final examination.

The MS or MEng advisory committee is to be composed of the faculty advisor (acting as the chair of the committee) and a minimum of two other faculty members. The faculty advisor and at least one of the committee members must be from the Graduate Catalog's approved list of Engineering Mechanics faculty (i.e., either a BEAM faculty member or an official program affiliate). The third member must be approved by the Graduate School to serve on a graduate committee. All committee members must be approved by the GPD and the Dean of the Graduate School. The committee must be selected and approved prior to submission of a Plan of Study. Students are encouraged to confer with a broad spectrum of the faculty and select those (willing) faculty members who best support their academic interests and/or research activities (as appropriate).

D. Final Examination

All MS and MEng students must pass an oral examination upon completion of the degree requirements. The Request to Admit Candidate to Final Exam form must be received by the Graduate School two weeks before the desired date. The student should work in consultation with the EM Program and their advisory committee to schedule the examination and the candidate must be registered for a minimum of three credit hours or have an approved *Start of Semester Defense Exception* (SSDE).

The examination is to be administered by the advisory committee, with additional members as needed to cover the examination material. The examination is expected to cover all mechanics course work as well as the research (for MS thesis) or project (for MEng) completed by the student. The GPD and the Graduate School must approve the examining committee. Students are encouraged to confer with their committee members prior to the final examination time for guidance regarding the expected scope and format of the examination.

In order to pass the final examination, a candidate is allowed at most one negative vote from the examining committee. If a student fails the final examination, there must be a lapse of one full semester (a minimum of 15 weeks) before rescheduling the examination. The student is allowed no more than two opportunities to pass the final examination.

E. Thesis

The thesis should be a scholarly discourse on a topic approved by the student's advisory committee. It should demonstrate the student's ability to perform independent research of professional quality. The thesis is expected to be well organized and written clearly. Detailed guidelines for publication of the thesis are specified in the Graduate Catalog.

The title of the degree, which appears on the cover page, is *Engineering Mechanics.* An example graduate diploma is shown in Section II.

F. Continuing on to the PhD

Some students may elect to continue to the PhD after earning their MS degree. Students may do this by either (1) submitting a new Graduate School application for admittance to the PhD program or (2) submitting a change of degree program form. The change of degree program form requires approval of the academic advisor and the GDP and allows the student to continue on without reapplying to the program. Students should talk with their advisor and/or the GPD for advisement on which option to pursue.

Courses taken toward the MS can also count toward the PhD. If earning a thesis MS, please note that ESM 5994 (master's level research hours) ***cannot*** count toward your PhD dissertation research hours. The appropriate number of credit hours of ESM 7994 (doctoral level research hours) must be listed on the Plan of Study. Please consult the PhD degree requirements for more information.

A PhD Plan of Study, qualifying exam, preliminary exam, and PhD final exam are required.

Any transfer courses that are used to fulfill the MS requirements cannot be counted toward the PhD requirements, with the exception of double-counted courses taken by Virginia Tech students who are enrolled in the Accelerated Undergraduate/Graduate (UG/G) program. Please see the transfer credit section for more information.

V. Requirements for the Engineering Mechanics Degree of Doctor of Philosophy

A. Overview of Doctoral Degree Requirements

Students must satisfy the following requirements to earn a doctoral degree in engineering mechanics:

1. Satisfy the *Scholarly Ethics and Integrity Requirement* (see Section II.H)
2. Satisfy the *Diversity and Inclusion Requirement* (see Section II.I)
3. Complete‡ a minimum of 90 credits that can be included on the Plan of Study (see Section IV.B).
   a. Complete‡ a minimum of 35 credits of graded coursework, including the 5 core courses (see Section IV.B.2).
   b. Complete‡ a minimum of 4 credits of ESM 5944 Seminar.
   c. Complete‡ a minimum of 30 credits of ESM 7994 Doctoral Research.
4. Pass the program's *Qualifying Examination* (see Section IV.C).
5. Pass the program's *Preliminary Examination* (see Section IV.E).
6. Prepare a *Dissertation* (see Section IV.F) and pass the *Final Examination* (see Section IV.G).

B. Credit Hour Requirements for a PhD in Engineering Mechanics

To earn a doctoral degree in engineering mechanics, students must complete‡ a minimum of 90 credits that satisfy the following requirements:

- At least thirty-five (35) credits of coursework are required according to the program specifications listed in Section IV. B.1, and fourteen (14) of these credits must consist of the core coursework in Section IV.B.2.
- At least four (4) credits of ESM 5944 Seminar are required as described in Section IV.B.3.
- At least thirty (30) credits of ESM 7994 Doctoral Research are required as described in Section IV.B.4.
- The content of the remaining twenty-one (21) credits must be agreed upon by the student and their Advisory Committee.

Students must also comply with all requirements of the Graduate School.

‡ In this document, "completing" a course includes the requirement that the resulting grade be a C– or better for graded courses, a P for pass/fail courses, or an EQ for research or project/report credits. This is to comply with a VT Graduate School requirement as listed in the Graduate Catalog: 'Courses on the Plan of Study with grades below "C-" must be repeated.'

1. General Coursework Requirements

Students pursuing a doctoral degree in engineering mechanics are required to complete‡ a minimum of 35 credits of coursework that satisfies each of the following requirements. All of these courses must be taken for a letter grade (except for courses that are only offered on a pass/fail basis). The courses used to satisfy these requirements must be approved by the student's Advisory Committee and the GPD through submission of the Plan of Study.

1. Fourteen (14) credits of graded core coursework (see Section IV.B.2).
2. At least three (3) credits of additional graduate-level coursework in mathematics; see the GC for a current list of approved courses.
3. At least six (6) credits of additional ESM-designated graded coursework.
4. At least twelve (12) credits of additional graduate-level graded coursework in support of the chosen area of doctoral research.

Restrictions:

- No more than 3 credits of 4xxx-level coursework can be counted toward the required minimum 35 credits of coursework.
- No more than 3 credits of Independent Study (5974 or 6974) can be counted toward the required minimum 35 credits of coursework.
- A maximum of 15 credits of transfer coursework can be counted toward the required minimum 35 credits of coursework.
- A maximum of 6 credits of transfer coursework can be counted toward the required 14 credits of core coursework (see Section V.B.2.).

Students are expected to enter the doctoral program with a math background that includes the equivalent to the following two courses:

1. MATH 4564 Operational Methods (3 credits)
2. MATH 4574 Vector and Complex Analysis for Engineers (3 credits)

If the EM Program determines that a student does not have this background, the student is required to complete‡ these two courses prior to taking (or being exempted from) the *Qualifying Examination*; students are encouraged to complete these courses as early as possible. The above two MATH courses are *not* counted toward the minimum 35 credits of coursework required for a doctoral degree in engineering mechanics.

2. Core Coursework Requirements

Engineering mechanics doctoral students must complete‡ each of the following five (5) core courses prior to taking the *Qualifying Examination*:

1. ESM 5014 Introduction to Continuum Mechanics (3 credits)
2. ESM 5314 Intermediate Dynamics (3 credits)
3. ESM 5024 Introduction to Solid Mechanics (3 credits)

4. ESM 5054 Introduction to Fluid Mechanics (3 credits)
5. ESM 5004 Communicating Engineering Mechanics (2 credits)

Students are expected to complete all of the above core coursework requirements by the end of their fourth (4^{th}) semester of enrollment in the engineering mechanics program.

Students may substitute one or more graduate course(s) taken at another institution for any of these core courses. To substitute, (1) the previous course must be successfully transferred to Virginia Tech for credit toward the doctoral degree, and (2) the GPD and the student's Advisory Committee must approve the substitution. (Not all courses will qualify for approval, despite course name or content, or the grade received. Multiple transfer courses may be required to substitute for a single core course.) Transferred courses are *not* included in the calculation of the cumulative core-course GPA, which is used in determining exemption from the *Qualifying Examination*. Transfer courses may be substituted for a maximum of 6 credits of core coursework.

3. Seminar Requirement

Students pursuing a doctoral degree in engineering mechanics are required to complete‡ a minimum of 4 credits of ESM 5944 Seminar.

- Students are required to enroll in ESM 5944 during their first two semesters in the EM doctoral program. Requests for waivers of this requirement (in order to accommodate conflict with a course or a teaching assignment, for example) are to be submitted in writing to the EM Program no later than the *Course/Add* date for the semester in question. Students receiving this exemption are still required to fulfill the minimum requirement of 4 credit hours of ESM 5944.
- Any additional credits of ESM 5944 required by the student's Advisory Committee will be listed as *Supporting Courses* on the Plan of Study.

4. Research Credit Requirements

Students pursuing a doctoral degree in engineering mechanics are required to complete‡ a minimum of 30 credits of ESM 7994 Doctoral Research.

C. Qualifying Examination

Students pursuing a doctoral degree in engineering mechanics are required to pass the *Qualifying Examination* before taking the *Preliminary Examination*.

1. Format

The *Qualifying Examination* consists of one or more written and/or oral examinations based on the material covered by the core coursework described in Section B. Examination content will be tailored to address any deficiencies identified by each student's performance in the core coursework. Exam

content and grading will be overseen by an ad hoc *Engineering Mechanics Qualifying Examination Committee*.

2. Timing and retesting

- A student is eligible to take the *Qualifying Exam* after completing the core coursework described in Section B. Note that this means the student must have received a C- or higher in all the core coursework before taking the *Qualifying Exam*. If a grade of less than C- is obtained in any core course, that course must be repeated until a grade of C- or higher is obtained.
- The *Qualifying Examination* must be taken prior to starting the fifth (5^{th}) semester of doctoral study in the engineering mechanics doctoral program. Students entering the program with an MS degree are strongly encouraged to take the examination prior to starting the third (3^{rd}) semester of doctoral study in engineering mechanics.
- The *Qualifying Examination* must be successfully passed before starting the seventh (7^{th}) semester of doctoral study in the engineering mechanics doctoral program. Students entering the program with an MS degree are encouraged to have passed the examination prior to starting the fifth (5^{th}) semester of doctoral study in engineering mechanics.
- Each student is allowed a total of two attempts to pass the *Qualifying Examination*. A student who fails the first attempt at the exam must retake it no later than 12 months after the first attempt. A student who fails the *Qualifying Examination* twice is not allowed to continue in the engineering mechanics doctoral program.

3. Exemptions

Students satisfying *both* of the following criteria are exempted from taking the *Qualifying Examination*:

- earn a B– or better in each of the core courses (see Section III B.1) that are taken at Virginia Tech, *and*
- attain a cumulative GPA of 3.2 or higher in the core courses (see Section III.B.2) that are taken at Virginia Tech.

D. Advisory Committee

Each graduate student must have an advisory committee, which guides and approves the Plan of Study, evaluates the student's academic progress, advises the student on their research, and conducts the preliminary and final examinations. The committee must be selected prior to the submission of a Plan of Study.

The PhD advisory committee is to be composed of the faculty advisor (acting as the chair of the committee) and a minimum of four (4) other faculty members. The faculty advisor and at least two of the other committee members must be from the Graduate Catalog's approved list of Engineering Mechanics faculty (i.e., either a BEAM faculty member or an official program affiliate). All members must be approved by the Graduate School to serve on a graduate committee. All committee members must be approved by the GPD and the Dean of the Graduate School. Students are encouraged to confer

with a broad spectrum of the faculty and select those (willing) faculty members who best support their academic interests and research activities.

E. Preliminary Examination

Students pursuing a doctoral degree in engineering mechanics are expected to take the *Preliminary Exam* not more than 12–18 months after passing the *Qualifying Exam*. A student's Plan of Study must be approved by the program and the Graduate School before the *Preliminary Examination* can be scheduled. Students are required by the Graduate School to pass the *Preliminary Examination* at least 6 months before taking their *Final Examination*.

The *Preliminary Examination* will consist of at least the three following components:

- a written dissertation proposal
- a public presentation of the proposed research
- a private oral examination by the student's Advisory Committee

Any additional expectations by the Advisory Committee must be communicated to the student in writing prior to the scheduling of the exam, and preferably at least 6 months prior to the exam.

1. Format

- The proposal is intended to be a plan of research for the student's doctoral dissertation. As such, the proposal should clearly document the individual studies that the student will conduct, their motivation, and their potential significance. The inclusion of preliminary data is encouraged, but not required. The length and format of the document will be specified by the student's Advisory Committee, but a concise document (e.g., an NSF-style 15-page proposal) is encouraged.
- Because the *Preliminary Examination* is expected to occur before the majority of the research is conducted, the proposal is not a contract *per se*, and some changes to the plan may arise in the course of conducting the research. Such changes should be clearly communicated with the student's Advisory Committee.
- The format of the public presentation will be specified by the student's Advisory Committee; a concise presentation is encouraged.
- The private questioning session immediately follows the public presentation. The questioning session is intended to provide sufficient basis for evaluating the student's ability to complete the doctoral degree requirements and succeed as an independent researcher. Therefore, questions by the committee members are expected to focus on the written document and the presentation, but they are not limited in any way.

2. Timing and retesting

- Students are eligible to take the *Preliminary Exam* after passing or being exempted from the *Qualifying Exam* described in Section IV.C.

- The written proposal should be submitted to the student's Advisory Committee at least two (2) weeks in advance of the public presentation and oral examination; exceptions to this timing must be approved by the student's Advisory Committee.
- Each student is allowed a total of two attempts to pass the *Preliminary Examination*. A student who fails the *Preliminary Examination* on their second attempt will be dismissed from the Graduate School upon completion of the current academic term.
- A student planning to retake the *Preliminary Exam* is expected to work with their Advisory Committee to (1) justify a second attempt at the exam and (2) develop a remediation plan that addresses the steps needed to prepare for that second attempt. This justification and remediation plan must be submitted to the GPD as a written document.
- A student is allowed to retake the *Preliminary Exam* no sooner than one semester (15 weeks) and no later than 12 months after the first attempt.

F. Dissertation

The dissertation should be an original contribution to the literature in the field of mechanics. Style and organization requirements are described in the Virginia Tech Graduate Catalog. The dissertation must be *completed by the student and read by the advisory committee* prior to scheduling the final examination. The style, organization, and standards of the dissertation shall be consistent with those for papers in the Journal of Applied Mechanics.

The title of the degree, which appears on the cover page, is *Engineering Mechanics.* An example graduate diploma is shown in Section II.

G. Final Examination

All PhD students must pass an oral examination upon completion of the degree requirements. All final examinations must be scheduled with the Graduate School at least two weeks before it is held and cannot be scheduled any sooner than six months after the acceptance of the proposal. The candidate must be registered for a minimum of three credit hours or have an approved *Start of Semester Defense Exception* (SSDE) at the time of the examination.

The examination is to be administered by the student's Advisory Committee, with additional members added as deemed necessary. The GPD and the Graduate School must approve the examining committee. The examination is expected to consist primarily of a defense of the dissertation. The dissertation must be *completed by the student and read by the advisory committee* prior to scheduling the final examination.

In order to pass the final examination, a candidate is allowed at most one negative vote from the examining committee. If a student fails the final examination, there must be a lapse of one full semester (a minimum of 15 weeks) before rescheduling the examination. The student is allowed no more than two opportunities to pass the final examination. A student who fails the *Final Examination* on their second attempt will be dismissed from the Graduate School upon completion of the current academic term. More information about this policy can be found in the Graduate Catalog.

H. Earning an MS "along the way"

PhD students have the option (but not the obligation) of obtaining an MS "along the way" as they complete the coursework requirement of the PhD (irrespective of whether they entered with or without an MS degree from elsewhere). In most cases, students continue their PhD studies, but in some cases a student may leave the program with just the MS degree. An MS Plan of Study and MS final exam are required.

PhD students can choose to earn either a non-thesis MS or a thesis MS "along the way". In general, courses taken at Virginia Tech toward the PhD can count toward both the PhD and an MS degree. If choosing a thesis MS, please note that ESM 7994 (doctoral level research hours) ***cannot*** count toward master's thesis research hours, and the appropriate number of ESM 5994 (master's level research hours) must be on the Plan of Study; please consult the MS degree requirements for more information. Furthermore, the contents of the PhD dissertation must be distinct from the MS thesis. Therefore, it is typically the non-thesis MS degree that is earned "along the way".

Any transfer courses that are used to fulfill the PhD requirements cannot be counted toward the MS requirements (and vice versa), with the exception of Virginia Tech students enrolled in the Accelerated Undergraduate/Graduate (UG/G) program who have pre-approved transfer coursework. Please see the transfer credit section for more information.

Appendix A

Scholarly Ethics and Integrity Requirement

Beginning in Fall 2014, all Virginia Tech graduate students are required to satisfy the *Resolution to Include a Scholarly Ethics and Integrity Component in Graduate Education* (CGS&P Resolution 2012-13B). Students in the EM Program satisfy the *Scholarly Ethics and Integrity Requirement* by completing the following two ***mandatory*** activities:

1. **Attend the EM program orientation.** Attendance is taken at this orientation and will be recorded in each student's record. During orientation, the Engineering Mechanics Ethics and Integrity Requirements are presented, and students are informed of the timeline for satisfying these requirements. Orientation includes presentations/discussions on EM and Graduate School policies and procedures, introduction to the Virginia Tech Graduate Honor System, and campus resources for assessing conduct and reporting misconduct. Students are expected to complete this requirement prior to the first semester of enrollment. Students who enroll late or are otherwise unable to attend the EM orientation prior to the first semester of enrollment are required to attend orientation before their third semester of enrollment.
2. **Complete the NSF Responsible Conduct of Research (RCR) requirement as implemented at Virginia Tech.** Completing the on-line course created and maintained by the Collaborative Institutional Training Initiative (CITI) satisfies this requirement. On completion of this course, students are awarded a certificate of completion. This certification must be submitted to the GC within the first month of graduate enrollment; the certificate will be recorded in the student's record.

The completion of the *Scholarly Ethics and Integrity Requirement* will be noted in the Plan of Study submitted for EM Program and Graduate School approval.

Failure to complete the *Scholarly Ethics and Integrity Requirement* within 12 months of enrollment will affect eligibility for financial support on assistantships and scholarship awards.

The proposed procedure for the EM *Scholarly Ethics and Integrity Requirement* satisfies the four required topics enumerated in the Appendix to CGS&P Resolution 2012-13B in the following specific ways:

Required Topic 1: Plagiarism and other violations of the Graduate Honor Code

The definition of plagiarism and responsibilities of graduate students as research participants is covered in the module of the CITI online course entitled "Introduction to Responsible Conduct of Research." Specific examples and information on best practices are given within the following modules: "Research Misconduct," "Publication Practices and Responsible Authorship," and "Data Acquisition, Management, Sharing and Ownership." In addition, the EM program orientation introduces students to Virginia Tech resources on plagiarism and other violations of the Graduate Honor Code; specifically those resources at the Graduate Honor System and the Virginia Tech Library System's "Outline of Plagiarism and how to avoid it" (https://guides.lib.vt.edu/c.php?g=658932&p=4625922).

Required Topic 2. Proper use of professional conventions in citation of existing research and scholarship, accurate reporting and ownership of findings, and acknowledgement of contributions to the work

This required topic is covered in the module of the CITI on-line course entitled "Publication Practices and Responsible Authorship." In addition, the EM program orientation introduces students to Virginia Tech resources on proper citations of existing research, the reporting and ownership of findings, and the acknowledgement of contributions of work. These resources include those available at the Graduate Honor System, the "Information Appropriately" module from VT Libraries, and the ""Research Integrity" available from the Virginia Tech Research Office.

Required Topic 3. Ethical standards in teaching, mentoring, and professional activities

This required topic is covered in the CITI on-line course modules entitled "Conflicts of Interest and Commitment," "Mentor/Trainee Responsibilities," "Peer Review," and "Collaborative Research." In addition, the EM program orientation introduces students to Virginia Tech resources on ethical standards in teaching, mentoring, and professional activities. In particular, Virginia Tech courses on training on research misconduct are provided through the Office of the Vice President for Research and Innovation. The CITI program provides information on the procedures and approval requirements for the use of human subjects in research. Finally, Research and Innovation provides conflict of interest training and resources.

Required Topic 4. Available avenues for reporting alleged misconduct

The available avenues for EM graduate students to report alleged misconduct are presented at the required EM program orientation. The particular avenues available to students include the Graduate Honor System and the Committee on Faculty Ethics. Both are presented and described. Examples of how these resources can be used are provided based on situations that have previously arisen in the EM graduate program.

Optional Topics

In addition to the required topics detailed above, the CGS&P resolution also includes a number of optional topics that may be covered by the EM Ethics and Integrity Requirement. The EM program orientation addresses intellectual property issues and the use of VTIP, guidelines for determination of authorship, proper purchasing procedures, and appropriate use of university facilities and equipment (including computing resources). Individual laboratory procedures and documentation policies, including IRB approval, varies by research group, and will be handled by the student's faculty advisor or laboratory supervisor.