Graduate Studies Handbook

University of Notre Dame
Department of Aerospace and Mechanical Engineering

AEROSPACE
AND MECHANICAL
ENGINEERING

2019 – 2020 Academic Year

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Available online at http://ame.nd.edu/graduate-programs/graduate-handbook

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I. INTRODUCTION

This handbook describes the policies and procedures for graduate studies in the Department of Aerospace and Mechanical Engineering (AME) of the University of Notre Dame. Included in this document are resources pertaining to:

- Basic responsibilities and standard operating procedures for graduate students;
- Requirements for the degree programs;
- Information about University and Department resources to support students.

This handbook is intended to provide general guidelines for AME graduate students, and it is recognized that exceptions will occur. All students are expected to have read these guidelines. If under any circumstances a student wishes to deviate from these guidelines, they should secure prior written approval from the Director of Graduate Studies and ensure that the approval is recorded in their permanent file.

A. General Resources

- The Graduate School (https://graduateschool.nd.edu/) provides a number of resources for current graduate students ranging from information about career services and family support resources to deadlines for graduation and commencement. Information for current students can be found at: https://graduateschool.nd.edu/current-students/
- The Graduate School's annual *Graduate Bulletin of Information* and the *Graduate School Academic Code* are the primary source for policies pertaining to all graduate students at the University. Nothing in this handbook is to be interpreted as contrary to these regulations of the Graduate School. Both documents can be found at: https://graduateschool.nd.edu/policies-forms/forms-policies-procedures/
- The *du lac: A Guide to Student Life Handbook* provides information on student services, student life, and student government. In particular, students should review this document and be aware of the policies regarding discriminatory and sexual harassment as they will be serving at times in positions of teaching authority during their graduate program. This can be found at: https://dulac.nd.edu/

B. Organization of the Department

In AME, all policy-making and administrative authority on graduate studies resides with the Graduate Studies Committee (GSC), composed of the Department Chair, the Associate Department Chair, the Director of Graduate Studies (DGS), and elected department faculty members. The administration of the program (paperwork, etc.) is handled by the Graduate Program Administrator. For the 2019/2020 academic year, these are as follows:

- ***Department Chair***: Prof. Kenneth Christensen (kchrist7@nd.edu)
- ***Associate Department Chair***: Prof. Jim Schmiedeler (jschmie2@nd.edu)
- ***Director of Graduate Studies (DGS)***: Prof. David Go (dgo@nd.edu)
- ***Graduate Program Administrator***: Gail Small (gsmall@nd.edu)

The student's primary contact for all graduate program matters is the faculty member who serves as the student's research advisor. For issues about policies and procedures or grievances, the student should reach out to the DGS, and for issues regarding paperwork, the student's academic record, or other administrative questions, the student should reach out to the Program Administrator.

Appeals and Grievances

Appeals of decisions related to academic matters, grievances of course grades or conduct, conflicts between students and advisors, or other issues that affect a student's degree progress will be addressed by the DGS under consultation with the GSC. Students wishing to file a formal grievance or appeal should do so in writing to the DGS *or* to the Department Chair. The student should indicate the nature of the problem, the date(s) the problem occurred, the grounds upon which the appeal is based, background information that the student considers important, and the relief requested. The matter will be considered by the DGS and Department Chair in consultation with the GSC, and acted on in no more than 15 working days. If the student feels the resolution is inadequate, they may appeal the decision to the Graduate School by following the formal procedures.[1]

Additional support for students comes in the form of the Graduate School Ombudperson, who serves as a resource for graduate students to confidentially discuss progress issues, mentorship concerns, or seek guidance from a neutral party about their studies. More information can be found at: https://graduateschool.nd.edu/current-students/graduate-school-ombudsperson/

II. Basic Responsibilities

A. Stipend Support and Professional Responsibility

Most full-time students receive a monthly stipend from the department. Funds for these stipends typically come from the externally-funded grants and contracts of the student's advisor or from internal sources through the Graduate School. It is expected that full-time students receiving financial support from the University devote all of their professional efforts to research, teaching, and course work within the University. While the department will endeavor to maintain or increase the stipend level every year, it cannot be guaranteed that the level of support will remain constant or increase throughout a student's time in the program.

Those students who are receiving stipend support in any form from the University must receive approval from their advisor, the DGS, and the Graduate School prior to pursuing *any* employment outside the Department that will be in conjunction and simultaneous to their graduate studies. Students who are funded by external fellowships, such as the National Science Foundation Graduate Research Fellowship, are expected to follow the guidelines and requirements of the fellowship program.

Any extracurricular activities that require a significant time commitment such as the Notre Dame marching band, intramural coaching or refereeing, or any form of instruction (other than assigned TA responsibilities), must be approved by the student's advisor.

[1] http://graduateschool.nd.edu/assets/9047/info_appeal_procedure.pdf

B. Vacations and Time Off

Students are allowed the following University holidays:

- the Wednesday before Thanksgiving, Thanksgiving and the following Friday,
- Christmas Eve through New Year's Day,
- Good Friday and Easter Monday,
- Memorial Day,
- Independence Day.

Students are expected to be present during Fall Break, Spring Break, and breaks before each semester as well as during the summer session. Any extra vacation time during periods in which the student is receiving financial support must be approved by the student's advisor.

Students receiving University support as a Teaching Assistant (TA) must be available throughout the semester, and three days beyond the end of final exams, to support the courses for which they have responsibility. Any absence from campus by a TA during the semester must be approved in writing by the student's research advisor and the instructor in the course for which the student is serving as a TA.

C. Teaching Assistant Responsibility

As part of their professional development, all graduate students are required to contribute to the academic mission of the Department during the time they are on-campus students. This typically involves working with a faculty member to aid in teaching a course. The graduate student may conduct labs or recitation sessions, grade homework or exams, help develop new learning activities, or hold office hours to provide assistance to students.

Students currently or previously supported by Graduate School or Department funds or external grants/contracts must contribute approximately 70 hours of work per semester (minimum of 60 hours and maximum of 80 hours) as a teaching assistant in the Department. The number of hours in a given week is typically 4 hours and will not exceed 18 hours. Students holding external fellowships may be exempt from this requirement and should comply with the guidelines and requirements of the fellowship program.

Second year and later students who receive stipend support from University sources (as opposed to external grants) may be required to dedicate more time to their TA duties, nominally 16 hours per week. This may depend on the level and type of support and is handled on a case-by-case basis.

Ph.D. students at or near the end of their program can petition for a single semester of dissertation writing status (ABD). For a graduate student on dissertation writing status whose full stipend support comes from external sources, the commitment is waived for one semester. If that student remains on campus in the Ph.D. program after the dissertation semester, they will once again be expected to participate each remaining semester at a level dependent upon the source of their stipend. Students who receive full or partial stipend support from University sources can also request dissertation writing status but are expected to nominally be engaged for 8 hours per week in TA duties during their ABD semester.

D. Registration and Enrollment

All graduate degree programs in AME have a set number of credit-hour requirements (see Section III) and these include both courses and research credit. All students therefore, are required to both register and enroll before each Spring and Fall semester to maintain student status; otherwise they have to apply for re-admission. The only exception is for officially approved leaves of absence. Specific requirements are as follows:

- ***First year***: 12 credit hours each Fall and Spring semester during their first year. These 12 credits may be coursework or a mix of coursework and research credits, dependent upon the advisor's discretion. For research credits, students should register for *AME 68691 Thesis Research*.
- ***Beyond first year***: minimum of 9 credit hours must be taken each Fall and Spring semester until all course and research credit requirements are met for the degree. Students that have not completed their candidacy exam or are pursuing a terminal M.S. should register for *AME 68691 Thesis Research*. Students that have completed their candidacy exam should registrar for *AME 98991 Dissertation Research*.
- ***Every summer session****:* All students are required to register and enroll for the zero-credit course *AME 67890 Independent Summer Research* during each Summer session.[2]

For entering students, registration and enrollment is done two days prior to the beginning of classes. For continuing students, registration is in the middle of the prior semester, with the subsequent enrollment the day before classes begin

Graduate students are allowed to audit graduate courses, and these courses appear on the student's official transcript with an audit designation. Information on auditing courses can be found on the Registrar's website.[3]

E. Advising and Annual Review

Advisor Selection

One of the most important aspects of graduate education is the relationship between the student and their faculty advisor. In the Department of Aerospace and Mechanical Engineering, students typically will work with their admission advisor. However, during the Fall semester of their first year, students may reach out to other faculty whose research and/or advising style is better aligned with the student. Official advisor selection occurs at the beginning of the Spring semester. Students will submit their advisor of choice, who then will be asked to accept the student and commit to paying the student's annual stipend. If a student has not identified and has not been accepted by a research advisor by the end of the second semester in the program, they will be dismissed from the program.

In most cases, individual students and faculty members make this arrangement without external intervention. In some cases, a student identifies two faculty members, typically collaborators, that

[2] Those expecting to obtain terminal degrees in August must register for zero credit hours of research under their advisor unless additional credit hours are needed to fulfill degree requirements. More information regarding this policy can be found in the Graduate School's Bulletin of Information.

[3] http://registrar.nd.edu/students/audit.php

agree to serve as co-advisors, with one designated as the *advisor* and one as the *co-advisor*. In these cases, it is acceptable for the co-advisor to be a faculty member outside of AME.

Good Standing and Annual Review

In order to be good standing with the Graduate School, students must maintain a cumulative grade point average (GPA) of 3.0; any student whose cumulative GPA is below 3.0 or whose GPA in any given semester is below 2.5 may be subject to loss of financial support and/or dismissal. The University follows a standard 4.0-basis grading system, as described by the Registrar.[4] For graduate students, a grade of C is the lowest acceptable passing grade.

Each student's progress toward their degree is reviewed annually in the Fall semester by the student's advisor in conjunction with the DGS and GSC. Continued financial support, both stipend and tuition, is dependent upon successful performance in research, course work, and TA duties, as well as the availability of funds. This review process consists of the following steps:

- The student fills out the Progress Checklist form[5] and sends it to their advisor and the Program Administrator.
- The student arranges to discuss their progress with their advisor; any issues are identified and addressed.
- The DGS and GSC in collaboration with the student's advisor review the student's progress and if there are concerns, remedial action is taken in the form of a written notice.

Both through this annual review and outside of it, graduate students are encouraged to openly discuss and establish research and progress expectations with their advisor. The relationship between the faculty advisor and graduate student is critical to the success of both individuals. A key element to developing a positive and supportive relationship between advisors and students is the establishment of shared expectations. The Graduate School provides a good framework for engaging in these conversations as found here:
https://graduateschool.nd.edu/graduate-training/intellectual-community/sharedexpectations/

F. Professional Development and Career Planning Requirements

Preparation for a career beyond graduate school is an important part of the AME graduate program. This includes not only career guidance but a holistic development of the student to be conversant across a breadth of topics in aerospace and mechanical engineering. To facilitate this, students must also meet the following requirements:

- ***AME Graduate Seminar***: All students must enroll in *AME 63999 Graduate Seminar*, a 0-credit pass/fail course. every Fall and Spring semester. The guidelines for participation in the Graduate Seminar are distributed at the beginning of each semester.
- ***Teaching Assistant Training Course***: All first-year students must register for *GRED 60501 Teaching Engineering Tutorials and Laboratories*, which is offered by the Kaneb

[4] https://registrar.nd.edu/students/gradefinal.php
[5] http://ame.nd.edu/resources/forms

Center only during the summer. The course addresses aspects of professionalism, learning styles, classroom procedures, characteristics of Notre Dame undergraduate students, sensitivity to diversity, etc. The course is subject to summer tuition and students must request a tuition scholarship through the Summer Session's online form accessible to students in late March/early April. Failure to request a summer tuition scholarship may result in the student being responsible for the cost of summer tuition. Note that the timing and exact dates of the course vary every year, and students are expected to adjust any summer travel plans to ensure attendance at the course.

- ***Career Planning***: All students intending to obtain a Ph.D. are required to schedule a one-on-one sit down session with a graduate career consultant from Graduate Career Services[6] during their first and third years of study. The purpose of the requirement is to assist the student in understanding and navigating their career options while taking the steps necessary to achieve their career goals.

G. Safety

The Department supports a number of office complexes and research laboratories. Students are responsible for acquainting themselves with and following all safety procedures for the laboratories they use. Safety training is managed online by ComplyND[7], and all graduate students are required to take the Basic Safety Training and Fire Extinguisher Training as part of their teaching assistant duties. All students are automatically signed up for these online courses and directly emailed information on how to complete them. (Note that this information is sent to the Notre Dame email account.) Additional training may be required depending on research duties, and students should discuss these requirements with their advisor. Questions about safety training and ComplyND should be directed to the AME safety coordinator Nancy O'Connor in the Department office.[8]

H. Non-Resident Status

On occasion, students spend part of their graduate program under non-resident status. Students should carefully discuss all aspects of such an arrangement with their research advisor prior to departure. Students who leave prior to completing their degree program and graduating that intend to eventually receive their degree must be registered as a student in the semester prior to intended graduation. Students will be responsible for the tuition costs associated with that registration.

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[6] https://gradcareers.nd.edu/ Current career consultant for Engineering is Larry Milks (lmilks@nd.edu)

[7] https://comply.nd.edu/

[8] nmee@nd.edu

III. DEGREE PROGRAMS

This section describes the Department's requirements for the M.S. (non-thesis), M.S. (thesis), and Ph.D. degrees. Additional details of University requirements, including residency and degree eligibility requirements, are in the *Graduate Bulletin of Information*.[9] Appendix C shows a short summary of requirements for each degree along with tables outlining 'typical' degree programs.

A. General Course Information

For all graduate degrees (M.S. and Ph.D.), graduate courses that satisfy degree requirements include both AME and non-AME courses, but only graduate courses offered by departments in the Colleges of Engineering or Science can be applied to degree requirements. Introductory graduate-level courses are 60000-level, special graduate courses are numbered 70000-level, and advanced graduate courses are 80000-level or 90000-level.

To help organize requirements, graduate courses satisfying degree requirements fall within three categories:

- Mathematics – including fundamental and specialization (Appendix D.1)
- Techniques – including numerical or experimental methods (Appendix D.2)
- Research pillar – select AME and non-AME courses aligned with AME research pillars (Appendix D.2)

For all AME degree programs, there is no required sequence of courses as long as all requirements are met. That is, there is flexibility in the order courses may be taken within and across the three categories, with the only exception being specific courses that have a pre-requisite requirement. Students should discuss the best sequences for their coursework with their advisor prior to signing up for any course work.

For the final category, all non-mathematics graduate courses in AME are organized along the 5 research pillars of:

- Fluid Mechanics and Aerodynamics
- Bioengineering
- Robotics and Dynamics
- Computational Engineering
- Materials & Thermal Science and Manufacturing

Requirements for the Ph.D. degree require students to take specific courses from their designated pillar as outlined in the following sections. Students should discuss with their advisor to identify their research pillar prior to signing up for any course work.

In general, only 60000-level or higher courses satisfy degree requirements. With the prior written approval (*i.e.*, prior to taking the course) of the DGS, credit can be received for 40000- or 50000-level courses offered in the Colleges of Engineering and Science as follows:

- A maximum of 6 credit hours (2 courses) for the M.S. (thesis) degree;

[9] https://graduateschool.nd.edu/policies-forms/forms-policies-procedures/

- A maximum of 9 credit hours (3 courses) for the M.S. (non-thesis) degree.

Such credit will not be given for work that is considered remedial.

B. Master's Degree (Non-Thesis)

The M.S. degree (non-thesis) program has two primary requirements. The first is the required credit hours, which consist of both coursework and research credit. The second is an oral presentation on a project or similar effort to a committee of AME faculty. These are outlined in the following.

The M.S. (non-thesis) degree is generally not an option for students receiving financial support from the department. Students receiving financial support from the department must obtain the approval of their advisor and the Department Chair prior to matriculating into the M.S. (non-thesis) program.

Credit Hour and Coursework Requirements for the M.S. Degree (non-thesis)

A minimum of 30 credit hours must be completed to receive this an M.S. degree (non-thesis), allocated as follows:

- at least 24 credits hours of coursework (8 classes)
- at least 6 credits of thesis research (AME 68691)

There are no specific class requirements other than the courses must be graduate courses as outlined in Section III.A above.

Final Examination

The final examination for the M.S. (non-thesis) degree is an oral examination by a committee of Department faculty. This committee consists of a minimum of three faculty members, normally the faculty advisor plus two other members of the AME Graduate Faculty (see Appendix B). Permission to include others on the committee must be granted by the DGS in consultation with the Graduate Studies Committee.

The examination begins with a 20-30 min presentation by the candidate. The presentation topic or project will be decided upon by the student and their advisor. After the presentation, the faculty advisor calls for questions from members of the committee. After the examination, the faculty advisor excuses the candidate and calls for discussion followed by a vote of committee members. A candidate passes upon either the unanimous consent or the consent of all except one member.

The student should coordinate scheduling this examination with the Program Administrator, and must be at least one week in advance of the intended date. Typically, a written document is not required for the final examination, but in some instances the advisor may request the student to do so.

C. Master's Degree (Thesis)

The M.S. degree program (thesis) has two primary requirements. The first is the required credit hours, which consist of both coursework and research credit. The second is a written thesis outlining an original research contribution by the student followed by an oral presentation and

defense of the thesis to a committee of readers consisting primarily of AME Graduate Faculty. These are outlined in the following.

The M.S. (thesis) degree is generally not an option for students receiving financial support from the department. Students receiving financial support from the department must obtain the approval of their advisor and the Department Chair prior to matriculating in the M.S. (thesis) program.

Credit Hour and Coursework Requirements for the M.S. Degree (thesis)

A minimum of 30 credit hours must be completed to receive an M.S. degree (thesis), allocated as follows:

- least 18 credits hours of coursework (6 classes)
- at least 12 credits of thesis research (AME 68691)

The 18 credits hours of coursework (6 classes) must be graduate courses as outlined in Section III.A with one required course as follows:

- one Mathematics Fundamentals course as defined in the list in Appendix X.A.

Thesis Preparation

All M.S. (thesis) students must write a thesis, which is generally completed during the third or fourth semesters. The final version of the thesis must conform to the format requirements as outlined by the Graduate School.[10] The thesis *must* be checked by the Graduate School for conformity to the guidelines before final submission.

When the thesis is complete, the student's advisor signs the form to indicate final approval and its readiness for the committee of readers.[11] The readers are selected by the student in conjunction with their advisor and submitted for approval to the DGS in consultation with the Graduate Studies Committee. There must be at least two readers, besides the advisor, who are members of the AME Graduate Faculty (Appendix B). Additional readers from other departments at Notre Dame are allowed. Readers from outside the University are allowed with prior permission of the DGS. In general, individuals from outside the University should be on the faculty at another university or otherwise have a record of scholarly activity. Company/corporate individuals involved in a student's research may be added as additional committee members, but only upon prior approval from the DGS.

To be accepted, the thesis must be approved by at least two readers; the advisor may not be one of the official readers. The readers report their decision on the appropriate form to the Graduate School.

Thesis Defense

The final examination for the M.S. (thesis) degree is an oral examination by the committee of readers that covers the area of the thesis, commonly called a thesis defense. The examination begins with a 30-45 minute presentation by the candidate. This presentation is open to the public.

[10] https://graduateschool.nd.edu/policies-forms/doctoral-dissertations-masters-theses/
[11] http://ame.nd.edu/resources/forms

The presentation should review the major elements of the thesis and should be primarily directed to the thesis readers. After the presentation, the thesis advisor calls for questions from members of the committee as well as the general audience, followed by the dismissal of the general audience. Additional questioning by the committee is then conducted in private after excusing the public audience. After the examination, the thesis advisor excuses the candidate and calls for discussion followed by a vote of committee members. A candidate passes upon either the unanimous consent or the consent of all except one member of the committee.

The student should coordinate scheduling this examination with the Program Administrator. The completed thesis must be given to the committee of readers at least one week in advance of the intended date.

Publication of Master's Thesis

The Master's thesis serves as the scholarly record of the student's research and as such, is published and disseminated. After the oral examination and approval of the thesis format by the Graduate School, the student is required to upload a clear, print-quality PDF version of the complete thesis to the Library's electronic master's theses and doctoral dissertations (ETDs) repository.[12] The Library system allows students to have control over the electronic release of their thesis to protect their intellectual property where appropriate.

A. Ph.D. Degree

The Ph.D. degree program has four primary requirements. The first is the required credit hours, which consist of both coursework and research credit. The second is the completion of the qualifying exam, which must be accomplished prior to the student's fourth semester; at the completion of this exam the student is officially admitted to the Ph.D. program. The third is the completion of the oral qualifying exam, which requires both a written document and oral presentation and defense to a committee of readers consisting primarily of AME faculty; upon the completion the student is officially a Ph.D. candidate. The final requirement is a written dissertation outlining an original research contribution by the student followed by an oral presentation and defense of the dissertation to a committee of readers consisting primarily of AME Graduate Faculty.

These requirements are outlined in the following for students entering with a B.S. in mechanical or aerospace engineering or a similar field. The M.S. degree is not a prerequisite for the Ph.D. program, and students entering with an M.S. degree should refer Section E for adjustments to the program outlined below.

Credit Hour and Coursework Requirements for the Ph.D. Degree

A minimum of 60 credit hours must be completed to receive a Ph.D. degree, allocated as follows:

- at least 30 credits hours of coursework (10 classes)

[12] https://deposit.library.nd.edu/areas/etd

- at least 30 credits of thesis research (AME 68691) or dissertation research (AME 98991)

The 30 credits hours of coursework (10 classes) must satisfy the following requirements:

- 2 mathematics courses, one selected from the approved list of Mathematics Fundamentals and one from the approved list of Mathematics Specialization (Appendix D.1)
- 1 techniques course selected from the approved list (Appendix D.2)
- 3 core courses in the student's research pillar selected from the approved list (Appendix D.3)
- 2 breadth courses can be any 60000-level or higher course *that is not within the student's research pillar*, including outside of AME in the Colleges of Engineering or Science
- 2 elective courses that can be any 60000-level or higher course in the Colleges of Engineering or Science

No courses may double count and satisfy two requirements.

**Note that some advisors and some research pillars may have expectations beyond the 10 class minimum; students should discuss a suitable plan of study with their research advisor.*

Qualifying Examination and Admission to Ph.D. Program

The purpose of the Qualifying Examination (QE) is to (a) evaluate a student's readiness to pursue a Ph.D, and (b) provide formative feedback to the student. After completion of the QE, the student is considered for formal admission to the Ph.D. program. The QE consists of a written document and oral examination to a committee of AME faculty. Details of the timeline, committee selection, and organization of the QE can be found in Appendix E.1.

The written QE document is a 5-7 page document that demonstrates an *understanding of the fundamental science* underlying the content in one of two options:

- ongoing research, including the motivation, methods, and results;
- literature review of subject area(s) chosen by the student's advisor, which may include key papers specified by the advisor.

The student is encouraged to discuss the document and its content with their advisor. It is also recommended that the student make their committee aware of the document's content in advance. The written document is submitted to the student's QE committee 2 weeks prior to the oral exam.

The oral examination is an ~20 min presentation by the student on the content of the QE document followed by questions by the committee, such that the overall length of the presentation and oral exam is no more than 60 minutes total. Questions posed to the student by the committee will focus on the student's readiness for Ph.D. research, including gaps in understanding of the fundamental science underlying the content presented. Each committee member will provide their feedback directly to the student and advisor regarding the student's readiness for Ph.D. research, which may include recommendations for research direction, further preparation, and planned academic coursework. This feedback will be both verbal at the end of the exam and in written form by each committee member. The entire exam – presentation and examination by the committee – is closed to the public.

The QE exam must be completed before the beginning of the student's 4th semester**.** In order to be eligible to take the QE, the student must have completed a minimum of four (60000-level or higher) courses[13] that satisfy degree requirements and maintained a minimum cumulative GPA of 3.0.[14] The GPA is calculated based only on courses taken in the graduate program at Notre Dame. Students who do not meet the GPA requirement by the time of the latest window when they are eligible (immediately prior to the beginning of their fourth semester) are ineligible to remain in the Ph.D. program.

Upon completion of the QE, the student's advisor in consultation with their QE committee, the DGS, and the Graduate Studies Committee will make the decision to formally accept the student into the Ph.D. program after reviewing the student's academic record and QE performance. Students that do not receive admission into the Ph.D. program are typically given the option to complete an M.S. degree (non-thesis or thesis, as appropriate); details on the requirements for the M.S. programs are in Sections B (non-thesis) and C (thesis), respectively.

Ph.D. Candidacy Examination

The purpose of the Candidacy Exam is for the student to propose and defends a line of research that will lead to the completion of the Ph.D. After successful completion of the Candidacy Exam, the student is considered a Ph.D. candidate, with the only remaining requirement the completion of the dissertation and defense. Students who complete their Candidacy Exam are also eligible for an M.S. degree. The Candidacy Exam consists of a written dissertation proposal and oral examination to a committee of AME faculty.

The Candidacy Exam is administered by a committee that consists of the student's advisor(s) and at least three other faculty members. Typically, this committee will also serve as the student's Dissertation Committee. Unless special circumstances warrant, at least three members on the committee, including the student's advisor, should be members of the AME Graduate Faculty (see Appendix B). Additional readers from other departments at Notre Dame are allowed. Readers from outside the University are allowed with prior permission of the DGS. In general, individuals from outside the University should be on the faculty at another university or otherwise have a record of scholarly activity. Company/corporate individuals involved in a student's research may be added as additional committee members, but only after approval from the DGS.

The written dissertation proposal is an ~20 page document wherein the dissertation topic, research accomplishments to date, plan of research to completion of the Ph.D., and significance of expected original contributions of the research are summarized. The proposal should be limited to 8000 words, excluding the title page, table of contents, lists of figures/tables, figure/table captions, acknowledgements, and references, written in a 12-point font, and double spaced. Any deviation from this requirement should be approved by the thesis advisor. The written document is submitted to the student's Committee 3 weeks prior to the oral exam.

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[13] These courses must be taken at the University of Notre Dame, must be 3 credits or greater, and must be graded; AME63999 Graduate Seminar may not be counted.

[14] Students that have entered the Ph.D. program with an M.S. degree and have had transfer credits for four (or more) courses approved are only required to take one (60000-level or higher) course. Students that transfer credits for fewer than four courses must make up the difference with 60000-level or higher courses at Notre Dame.

The oral examination is by the Committee and explores the feasibility, originality, and significance of the proposed Ph.D. dissertation topic. The oral examination covers both material in the written dissertation proposal and in the general area of research. The examination begins with an approximately 30-45 minute presentation by the student. This presentation is open to the public. The presentation should review the major elements of the dissertation proposal and should be primarily directed to the student's committee. After the presentation, the student's advisor calls for questions from members of the committee as well as the general audience, followed by the dismissal of the general audience. The Committee then conducts a series of questions on both the presentation and material in the written proposal and which can include questions that are generally relevant to the student's area of research, but not covered in the presentation or proposal. After the examination, the student's advisor will excuse the student and calls for discussion followed by a vote of Committee members.

Both portions of the Candidacy Examination are passed or failed by a vote of the Committee. A student passes when at least all except one Committee member approves the defense of the work. That is, on a Committee of three, two votes in favor are required to pass, on a Committee of four, three votes are required to pass, and similarly on a committee of five, four votes are required to pass. In the case of a failure, the student may be allowed one re-examination by the Department Chair upon recommendation of a majority of the Committee members and the approval of the Graduate School.

The Ph.D. Candidacy Examination *must* be completed by the end of the eighth semester (4th year), or the student will be placed on probation by the Graduate School and forfeit their academic and financial eligibility. This may include the obligation for the student to pay for some or all of their credit hours for semesters beyond the eight semester, regardless if the student is supported by a Fellowship or research grant. Typically, the Candidacy Examination should be successfully completed near the end of their sixth semester (3rd year) in residence for students entering with their B.S. degree and prior to the fifth semester for students entering with their M.S. degree.

A Ph.D. student who has successfully completed all parts of the Candidacy Examination may receive a non-thesis Master's degree upon the student's request and the recommendation of the student's advisor, the DGS, and the Department Chair. Note that it is the policy of the University to not award duplicate degrees. A student who has a Master's degree in aerospace *or* mechanical engineering, whether from Notre Dame or another institution, *will not* be awarded a Master's degree on completion of the Candidacy examination.

Dissertation Preparation

All Ph.D. students must write a dissertation after completing the Candidacy Examination and their proposed research. The dissertation is a comprehensive report on the student's research, including the motivation and purpose, background and relevant prior work by others (literature), the methodology used in the research, results and findings (with suitable discussion), and conclusions. The dissertation should clearly demonstrate the student's original contribution to their research community. The dissertation typically is written in book-style, consisting of multiple chapters. It is important to note that the dissertation should outline a coherent line of research inquiry and not only collect papers the student has published. The student should work closely with their advisor on the format and content of their dissertation. The final version of the dissertation must conform

to the format requirements as outlined by the Graduate School.[15] The dissertation *must* be checked by the Graduate School for conformity to the guidelines before final submission. To avoid problems, students should use the Microsoft Word® document templates or LaTeX class files supplied by the Graduate School.

When the dissertation advisor(s) is satisfied that the dissertation is in suitable form, the advisor(s) will sign a Release of Ph.D. Dissertation for Distribution to the Doctoral Committee form[16], releasing the dissertation for distribution to the Dissertation Committee, who serve as readers. The student provides the Committee with copies of the dissertation, and in order for the student to defend the dissertation, it must be unanimously and unconditionally approved by all members of the Committee. Reader approval of the dissertation for defense does not imply reader agreement or support; it implies reader acknowledgment that the dissertation is an academically sound and defensible scholarly product. The Committee members report their decision on the Reader Form to the Graduate School.[17] Details of the timeline and procedures for dissertation approval and the dissertation defense can be found in Appendix E.3.

In nearly all cases, the Committee will consist of the same members from the student's Candidacy Examination and the same requirements for the composition of Committee apply (Appendix E). A candidate may petition the DGS and Graduate Studies Committee for any change in the composition of the Committee after the Candidacy Examination.

Dissertation Defense

The final examination for the Ph.D. degree is an oral examination by the Dissertation Committee that covers the area of the dissertation, commonly called a dissertation defense. The examination begins with a 30-45 minute presentation by the candidate. This presentation is open to the public. The presentation should review the major elements of the dissertation and should be primarily directed to the Committee. After the presentation, the student's advisor calls for questions from members of the Committee as well as the general audience, followed by the dismissal of the general audience. The Committee then conducts a series of questions on both the presentation and material in the written dissertation. After the examination, the student's advisor will excuse the student and calls for discussion followed by a vote of Committee members. Official notification of the results of the PhD dissertation defense will be sent to the student and their advisor(s) from the Graduate School. (See Appendix I for more detailed information.)

A candidate passes when at least all except one Committee member approves the defense of the work. That is, on a Committee of three, two votes in favor are required to pass, on a Committee of four, three votes are required to pass, and similarly on a committee of five, four votes are required to pass.

Failure of the defense does not necessarily require rewriting the dissertation. In the case of a failure, the student may be allowed a second opportunity to present a defense of their work based upon the recommendation of a majority of the Defense Committee members, the Department

[15] https://graduateschool.nd.edu/policies-forms/doctoral-dissertations-masters-theses/
[16] http://ame.nd.edu/resources/forms
[17] http://ame.nd.edu/resources/forms

Chair, and the approval of the Graduate School. Failure in the second defense terminates the candidate's eligibility for a Ph.D. at the University.

A student's dissertation and defense *must* be completed by the end of the eighth year in the graduate program, unless the student has received a special exemption. Failure to do so terminates the student's eligibility for a Ph.D. from the University.

Publication of Ph.D. Dissertation

The Ph.D. dissertation serves as the scholarly record of the student's research, and should be published and disseminated. After the oral examination and approval of the thesis format by the Graduate School, the Department requires the student to upload a clear, print-quality PDF version of the complete thesis to the Library's electronic master's theses and doctoral dissertations (ETDs) repository.[18] The Library system allows students to have control over the electronic release of their thesis to protect their intellectual property where appropriate.

D. Transferring Course Credits and Students Entering with an M.S.

Students Who Completed M.S. Degrees Prior to Notre Dame

There are some modifications to the Ph.D. program for students with either an M.S. degree from another university, or who hold an M.S. degree from Notre Dame but are coming back after an absence from the University

Student's may transfer up to 15 coursework credits (5 classes) from a master's degree obtained within a period no longer than five years prior to admission to Notre Dame may be made.[19] To receive credit for a graduate course taken elsewhere, the course must be a graded, graduate-level, academic course in engineering or science that would normally be considered as part of AME graduate academic course requirements. The student must have achieved a grade of a B or better. Pass/fail courses, research credits, M.S. thesis writing credits, or other credits not related to formal course work cannot be transferred. The DGS in consultation with the Graduate Studies Committee will make a determination if any of these credits can additionally satisfy any of the course requirements outlined above. A maximum of 6 hours of graduate course credit may be accepted from graduate courses completed elsewhere if no graduate degree was earned.

For those students entering with M.S. degrees, the Qualifying Examination should be taken at the earliest opportunity. If a student has not completed the QE prior to the start of their fourth semester, they will be dismissed from the program. In terms of eligibility to take the QE, students that have entered the Ph.D. program with an M.S. degree and have had transfer credits for four (or more) courses approved are only required to take one (60000-level or higher) course. Students that transfer credits for fewer than four courses must make up the difference with 60000-level or higher courses at Notre Dame.

[18] https://deposit.library.nd.edu/areas/etd

[19] See form at: http://ame.nd.edu/resources/forms

Students Who Completed Undergraduate Degrees at Notre Dame

Graduate students who completed undergraduate degrees at Notre Dame and took graduate level (60000 level or higher) courses that were not used to satisfy undergraduate degree requirements, can request up to 6 credit hours of qualified courses to satisfy graduate degree requirements.

IV. FACILITIES AND SERVICES

The University of Notre Dame offers a wide variety of services and facilities to support graduate students as they work toward their degree. Much of this information is collected for graduate students on the Graduate School website: https://graduateschool.nd.edu/

A summary of important items are listed below.

A. Facilities and Services to Support Research

Library

The University Library system consists of a number of libraries. Circulation policies and operating hours are available at each of the libraries. Students should make themselves aware of the resources the libraries provide and become more familiar with them by visiting the University library web site: http://library.nd.edu/

Computing Facilities

The Office of Information Technologies (OIT) oversees a variety of computers, workstation clusters, and personal computer facilities throughout campus. Some are open year-round, twenty-four hours a day. The University is fully networked and has a wide range of software and printing services available for the use of all students. For a complete current listing of University facilities, which change often, students should visit their web page located at http://oit.nd.edu.

The Center for Research Computing (CRC) provides a number of services for those in need of computing resources for research purposes, including access to high performance computing resources, access to large amounts of data storage, and support for software development, visualization, and systems design/acquisition. Students that require these resources should consult the CRC website at https://crc.nd.edu/.

Laboratory Facilities

A variety of research and instructional laboratories exist in the department. These are located primarily on the third floor of Fitzpatrick Hall and Cushing Hall, throughout the lower levels of Fitzpatrick Hall, in the Hessert Laboratory for Aerospace Research, White Field Laboratory, and in the Multidisciplinary Research Building (MRB) and Stinson-Remick Hall.

Office Facilities

All full-time graduate students have twenty-four hour access to personal office space in Cushing Hall, Fitzpatrick Hall, the Hessert Laboratory, MRB, or White Field. Offices are typically shared with other students. Each student will also have a mailbox located in or near the main administrative office in the building to which they have been assigned. Students are encouraged to use their office as a base for carrying out day-to-day academic activities. Students are expected to maintain professional office environments. If this is not the case, based upon the decision of the Department Chair, a student may lose the opportunity to have an on-campus office.

Printing and Copying Facilities

There are a number of copying facilities on campus, with services available at a charge. Many small machines are located in Hesburgh Library and each branch library. The Departmental copy machines are located in each of the Department buildings and policies associated with the use of the copy machines are established in each facility.

B. Facilities and Services to Support Professional Development

Graduate Student Union

Graduate students are responsible for the activities of the Graduate Student Union (GSU). Through a council of elected officers, appointed officers, and representatives from the departments of its constituent colleges, the GSU provides a variety of services and represents its membership on various University councils and committees. It publishes the bimonthly GSU newsletter, conducts a graduate orientation program, and sponsors workshops, travel grants, and various social and cultural activities. The GSU is the graduate students' official liaison with University administration, the Student Activities Office, and the Library Administration. The GSU finances operations through a yearly fee assessed on all graduate students. The GSU maintains offices in W206A Duncan Student Center. More information can be found at: https://gsu.nd.edu/

AME Graduate Organization (AMEGO)

The AME Graduate Organization (AMEGO) encompasses all graduate students in the AME Department. The mission of the AMEGO is to organize and facilitate social events for AME graduate students, provide a forum for the expression of AME graduate student opinions and concerns, as well as aiding in the orientation of new incoming students. All graduate students in the AME department are automatically members of the AMEGO. For the 2019-2020 academic year, the AMEGO president is:

- AMEGO President: John Park (hpark6@nd.edu)

C. Facilities and Services to Support Professional Development

Graduate Student Life

A unit within the Division of Student Affairs and in cooperation with the Graduate School, Graduate Student Life is committed to enhancing the educational experience and quality of life for Notre Dame students pursuing advanced degrees. The Graduate Student Life website contains reference links for special events and programs, family resources, information on wellbeing (including health and counseling services), and information regarding campus life in general. A helpful Q&A weblog to answer questions is also featured. More information can be found at: http://gradlife.nd.edu/

APPENDIX A: ACADEMIC INTEGRITY

In questions involving academic integrity the student is referred to the general policy found in the Graduate School *Bulletin of Information*.[20]

The Department expects all students to maintain and promote the highest standards of personal honesty and professional integrity. These standards apply to examinations, assigned papers, projects and preparation of the thesis or dissertation. Violation of these standards, which includes, but is not limited to cheating in examinations, plagiarism and fraudulent practices in conducting research or reporting the results of such research, may result in suspension or dismissal.

Within the Department, primary authority for judgment and decision on matters of academic integrity lies with the course instructor for issues, which arise in the classroom, or the faculty research advisor for issues that arise in research. Unsettled disputes should be referred first to the DGS and next to the Department Chair each of whom can serve as arbiters at the department level. Any further appeal should be directed to the Graduate School.

[20] https://graduateschool.nd.edu/policies-forms/forms-policies-procedures/

APPENDIX B: FACULTY

AEROSPACE AND MECHANICAL ENGINEERING GRADUATE FACULTY (2018-2019)

Department Chairman: Prof. Kenneth Christensen
Associate Department Chairman: Prof. James Schmiedeler
Director of Hessert Laboratory: Prof. Thomas C. Corke
Director of Graduate Studies: Prof. David Go
Director of Undergraduate Studies: Prof. J. William Goodwine, Jr.

Full Professors

Faculty Member	*PhD Institution*	*Year of Ph.D.*	*Research Area*	*Faculty Office Bldg.*
Robert Bernhard	Iowa State Univ.	1982	Engineering Mechanics	(NA)
Hsueh-Chia Chang*	Princeton Univ.	1980	Microfluids	(Fitz)
Kenneth Christensen	Univ. Illinois	2001	Fluid Mechanics	(Fitz)
Dipankar Choudhury**	Univ. Minnesota	1987	Comp. Fluid Mechanics	(NA)
Thomas C. Corke	Illinois Inst. Tech.	1981	Fluid Mechanics	(Hess)
Joseph Fernando*	Johns Hopkins Univ.	1983	Fluid Mechanics	(Cush)
David B. Go	Purdue Univ.	2008	Thermal Sciences	(McCrtny)
J. William Goodwine	Cal Tech	1998	Robotics	(Fitz)
Eric J. Jumper	Air Force Inst. Tech.	1975	Aerodynamics	(Cush)
Scott C. Morris	Michigan State Univ.	2002	Aero Fluids	(Hess)
Andrew Kennedy*	Monash Univ.	1998	Civil, Environmental, Earth Sc.	(Fitz)
Karel Matous	Czech Tech Univ.	2000	Comp. Science & Engr.	(Fitz)
Glen L. Niebur	Univ. California	2000	Biomedical/Mechanics	(MRB)
Timothy Ovaert	Northwestern Univ.	1989	Solid Mechanics/Tribology	(MRB)
Joseph M. Powers	Univ. Illinois	1988	Combustion	(Fitz)
Matthew Ravosa*	Northwestern Univ.	1989	Biomechanics	(Galvin)
Ryan K. Roeder	Purdue Univ.	1999	Biomedical/Materials	(MRB)
Steven R. Schmid	Northwestern Univ.	1993	Tribology	(MRB)
James P. Schmiedeler	Ohio State Univ.	2001	Robotics	(Fitz)
Flint O. Thomas	Purdue Univ.	1983	Fluid Mechanics	(Hess)
Gretar Tryggvason**	Brown Univ.	1985	Comp. Fluid Mechanics	(NA)
Meng Wang	Univ. Colorado	1989	Fluid Mechanics	(Hess)
Joannes Westerink*	M.I.T.	1984	Civil Engineering	(Fitz)
Nicholas Zabaras	Cornell Univ.	1987	Comp. Math & Science	(Cush)

Associate Professors

Faculty Member	*PhD Institution*	*Year of Ph.D.*	*Research Area*	*Faculty Office Bldg.*
Stanislav Gordeyev	Univ.of Notre Dame	1999	Aerodynamics	(Hess)
Edward C. Kinzel	Purdue Univ.	2010	Manufacturing/Thermal	(Fitz)
Tengfei Luo	Michigan State Univ.	2009	Thermal Sciences	(Fitz)
Ryan McClarren	Univ. of Michigan	2007	Nucl.Eng/Radiological Sci	(Fitz)
Svetlana Neretina	McMaster Univ.	2007	Material Sci/Nanomanuf	(Fitz)
Hirotaka Sakaue	Purdue Univ.	2003	Fluid Flow	(Hess)

**Concurrent professor; **Adjunct professor*

Michael M. Stanisic	Purdue Univ.	1986	Machine Kinematics	(Fitz)
Alexandros Taflanidis*	Cal. Inst. Tech.	2007	Computational Mechanics	(Fitz)
Pinar Zorlutuna	Middle East Tech	2005	Biotechnology/Biomedical	(MRB)

Assistant Professors

Faculty Member	*PhD Institution*	*Year of Ph.D.*	*Research Area*	*Faculty Office Bldg.*
Joel Boerckel**	Georgia Tech	2011	Biomechanics	(NA)
Martina Bukac*	Univ. of Houston	2012	Comp. Fluid Dynamics	(HURL)
Donny Hanjaya-Putra	Johns Hopkins Univ.	2012	Biomedical/Biomaterials	(MRB)
Maria Holland	Stanford Univ.	2017	Biomech/Computations	(MRB)
Seong-Kyun Im**	Stanford Univ.	2013	Exper. Fluid Dynamics	(Hess)
Thomas Juliano	Purdue Univ.	2010	Hypersonic Flows	(Hess)
MacArt, Jonathan	Princeton Univ.	2018	Fluid Mechanics Combustion	(Fitz)
Zhangli Peng**	Univ. of California	2011	Multi- scale/physics Mdlng	(Fitz)
Mark Plecnik	Univ. of California	2015	Robotics/Controls	(Fitz)
David Richter*	Stanford Univ.	2011	Turbulence	(Cush)
Tracy Vargo-Gogola**	Vanderbilt Univ.	2002	Biochemistry/Biomedical	(RC)
Jian-Xun Wang	Virginia Tech	2017	Fluid Mechanics	(Fitz)
Patrick Wensing	Ohio State Univ.	2014	Dynamic Systems/Controls	(Fitz)
Sangpil Yoon	Univ. Texas	2012	Acoustics/Biomedical	(MRB)
Matthew Zahr	Stanford Univ.	2016	Comp. Sci. & Engr	(Fitz)
Yanliang Zhang	Rensselear Polytech Inst.	2011	Thermal Science/Energy	(Fitz)

Research Associate Professors

Faculty Member	*PhD Institution*	*Year of Ph.D.*	*Research Area*	*Faculty Office Bldg.*
Robert Hughes	McMaster Univ.	1992	Physics	(Cush)
R. Mark Rennie	Univ.of Notre Dame	1996	Aerodynamics	(Hess)

Research Assistant Professors

Faculty Member	*PhD Institution*	*Year of Ph.D.*	*Research Area*	*Faculty Office Bldg.*
Gianluca Blois	Polytech Univ Milan	2007	Fluids	(Hess)
Joshua Cameron	Univ.Notre Dame	2007	Aero Fluids	(NA)
Aleksandar Jemcov	Univ.Belgrade	2004	Aero Fluids	(Hess)
Lee, Eungkyu	Seoul National Univ.	2015	Thermal Sciences	(Fitz)
Eric Matlis	Univ.Notre Dame	2004	Fluid Mechanics	(Hess)
Prakash Nallathamby	Old Dominion	2010	Nanotechnology	(MR

Special Professional Faculty

Faculty Member	*Institution/Degr*	*Year of Degree*	*Research Area*	*Faculty Office Bldg.*
Michael Seelinger	Univ. Notre Dame, PhD	1999	Robotics/ME Systems	(Fitz)

**Concurrent professor; **Adjunct professor*

Associate Special Professional Faculty

Faculty Member	*Institution/Degr*	*Year of Degree*	*Research Area*	*Faculty Office Bldg.*
John Ott	Univ. Notre Dame, MS	1998		(Fitz)
Richard Strebinger	RPI, M.S.	1983		(Fitz)

Assistant Special Professional Faculty

Faculty Member	*Institution/Degr*	*Year of Degree*	*Research Area*	*Faculty Office Bldg.*
Paul Rumbach	Univ. Notre Dame, PhD	2016		(Fitz)
Jing Wang	RPI, M.S.	2011		(Fitz)

Faculty Office Locations: (Cush) - Cushing; (Fitz) - Fitzpatrick Hall; (Hess) - Hessert Laboratory; (HURL) Hurley Hall; (MRB) - Multidisciplinary Research Building; (McCrtny) – McCourtney Hall; (RC) - Racklin-Carmichael; (WF) - White Field

**Concurrent professor; **Adjunct professor*

APPENDIX C: OVERVIEW OF REQUIREMENTS FOR EACH DEGREE PROGRAM AND TYPICAL DEGREE OUTLINE

Credit Requirements for Each Graduate Program
Required for all students:

- AME63999 Graduate Seminar (every semester)
- GRED 60501 Teaching Engineering Tutorials and Laboratories (summer after 1st year)
- AME67890 zero-credit summer research course (every summer)

	M.S. (non-thesis)	**M.S. (thesis)**	**Ph.D.***
Total Credits	30	30	60
course work (minimum)	24 (8 classes)	18 (6 classes)	30 (10 classes) **
research (nominal)	6	12	30
Notes		• *AME60611 Math Methods I* or other Math Fundamentals course required	• 2 math courses • 1 techniques course • 3 core courses in primary research pillar • 2 breadth courses (outside primary pillar) • 2 elective courses

* Ph.D. students must also complete career counseling in Years 1 and 3
** Students entering with an M.S. degree may transfer up to 15 credits, such that they require only 15 credits (5 classes) to complete their Ph.D.

Typical M.S. Degree Program (Non-Thesis)

Year 1	Fall	Courses: 12 hrs (4 classes) Research: 0 hrs
	Spring	Courses: 12 hrs (4 classes) Research: 0 hrs
	Summer	Research: 6 *for August graduation* ***M.S. Project Presentation***

Typical M.S. Degree Program (Thesis)

Year 1	Fall	Courses: 9 hrs (3 classes) Research: 3 hrs
	Spring	Courses: 9 hrs (3 classes) Research: 3 hrs
	Summer	GRED 60501 AME 67890 (Research: 6 hrs *if August graduation*)
Year 2	Fall	Research: 9 hrs ***M.S. Thesis Defense***

Typical Ph.D. Degree Program

		Students entering with B.S.	**Students entering with M.S.** *(assuming 15 credits transfer)*
Year 1	Fall	*Courses*: 9 hrs (3 classes) *Research*: 3 hrs	*Courses*: 9 hrs (3 classes) *Research*: 3 hrs
	Spring	*Courses*: 9 hrs (3 classes) *Research*: 3 hrs ***Qualifying Exam*** *(May window)*	*Courses*: 6 hrs (2 classes) *Research*: 3 hrs ***Qualifying Exam*** *(May window)*
	Summer	GRED 60501 AME 67890 ***Qualifying Exam*** *(August window)*	GRED 60501 AME 67890 ***Qualifying Exam*** *(August window)*
Year 2	Fall	*Courses*: 6 hrs (2 classes) *Research*: 3 hrs	Research: 9 hrs
	Spring	*Courses*: 6 hrs (2 classes) *Research*: 3 hrs ***Qualifying Exam*** *(January window)*	Research: 9 hrs ***Candidacy Exam***
	Summer	Research AME 67890	Research AME 67890
Year 3	Fall	*Research*: 9 hrs	Research: 9 hrs
	Spring	*Research*: 9 hrs ***Candidacy Exam***	Research: 9 hrs
	Summer	AME 67890	AME 67890 ***Ph.D. Dissertation Defense***
Year 4	Fall	*Research*: 9 hrs	
	Spring	*Research*: 9 hrs	
	Summer	AME 67890	
Year 5	Fall	*Research*: 9 hrs	
	Spring	*Research*: 9 hrs ***Ph.D. Dissertation Defense***	

APPENDIX D: PH.D. COURSES

Appendix D.1 Mathematics Courses

Students must complete one Mathematics Fundamentals course from the list below and one Mathematics Specialization course from the list below for the Ph.D. degree. No other Notre Dame courses will be accepted. Mathematics courses taken at another University as part of an awarded M.S. degree and transferred to Notre Dame may fulfill the mathematics elective requirement.

Mathematics Fundamentals
(one course from list below)
Department of Aerospace and Mechanical Engineering
AME 60611 Mathematical Methods I

Department of Mathematics
MATH 60210 Basic Algebra I
MATH 60330 Basic Geometry And Topology
MATH 60350 Basic Real Analysis I
MATH 60370 Basic Complex Analysis I

Mathematics Specialization
(one course from list below or any additional course from the Mathematics Fundamentals list)
Department of Aerospace and Mechanical Engineering
AME 60611 Mathematical Methods II
AME 60624 Continuum Mechanics
AME 70779 Applied Probability and Statistical Computing Methods for Scientists and Engineers

Department of Mathematics
MATH 60610 Basic Discrete Mathematics
MATH 60620 Optimization
MATH 60650 Basic Partial Differential Equations I
MATH 60670 Differential Geometry I
MATH 60850 Probability

Department of Applied and Computational Mathematics and Statistics
ACMS 60395 Numerical Linear Algebra
ACMS 60630 Nonlinear Dynamical Systems
ACMS 60650 Applied Partial Diff Equations
ACMS 60786 Applied Linear Models
ACMS 60790 Numerical Analysis II
ACMS 60850 Applied Probability
ACMS 60852 Advanced Biostatistical Methods
ACMS 60885 Applied Bayesian Statistics

Department of Civil & Environmental Engineering & Earth Sciences
CE 60123 Probabilistic Methods for Engineers and Scientists

Appendix D.2 Techniques Courses

The following courses are accepted to meet the techniques course requirement for the Ph.D. degree. No other Notre Dame courses will be accepted. Techniques courses taken at another University as part of an awarded M.S. degree and transferred to Notre Dame may fulfill the techniques course requirement with approval by the DGS.

Department of Aerospace and Mechanical Engineering
AME 60614 Numerical Methods
AME 60613 Finite Elements in Engineering
AME 60631 Experimental Methods in Fluids
AME 60644 Finite Elements in Structural Mechanics
AME 60735 Advanced Data Analysis Techniques

Department of Computer Science and Engineering
CSE 60113 Numerical Methods and Computation

Department of Mathematics
MATH 60620 Optimization
MATH 60690 Numerical Analysis I
MATH 60790 Numerical Analysis II
MATH 60850 Probability
MATH 60860 Stochastic Modeling
MATH 60920 Probabilistic Aspects of Linear Control and Optimization

Department of Applied and Computational Mathematics and Statistics
ACMS 50051 Numerical PDE Techniques for Scientists and Engineers
ACMS 60395 Numerical Linear Algebra
ACMS 60590 Finite Elements in Engineering
ACMS 60690 Numerical Analysis I
ACMS 60790 Numerical Analysis II
ACMS 60852 Statistical Methods in the Biological and Health Sciences
ACMS 60885 Bayesian Statistics

Department of Civil & Environmental Engineering & Earth Sciences
CE 60123 Probabilistic Methods for Engineers and Scientists
CE 60130 Finite Elements in Engineering
CE 60140 Applied/Computational Probability for Engineers

Department of Electrical Engineering
EE 60563 Probability and Random Processes
EE 60573 Detection and Estimation
EE 80603 Transmission Electron Microscopy

Department of Chemical and Biomolecular Engineering
CBE 60727 Ambient Methods of Surface Characterization

Appendix D.3 Pillar and Core Courses

All non-mathematics graduate courses in AME are organized along five research pillars as outlined below. Courses with an asterisk (*) are considered core courses. Students much complete at least three core courses in a single pillar plus any additional restrictions as listed for that pillar.

Note that some courses are still using 40000-level or 50000-level numbering designations. While 40000-level and 50000-level courses are nominally not supposed to count toward Ph.D. degree requirements, during the transition year of 2019/2020 (only), they will be allowed if they appear on these lists. Only two (2) 40000-level/50000-level courses may be counted, as permitted by the graduate school. Some 60000-level courses will also be renumbered as 70000-level courses in future years.

Fluid Mechanics and Aerodynamics
*AME 60635 Inter. Fluid Mechanics
*AME 90934 Viscous Flow Theory I (to be renamed as "Viscous Flow Theory" and to be numbered as 70000)
*AME 90935 Turbulence (to be numbered as 70000 after "Viscous Flow Theory")
AME 60630 Intermediate Compressible Flows
AME 60632 Physical Gas Dynamics
AME 60638 Turbine Engine Components
AME 60639 Advanced Aerodynamics
AME 60731 Surface Flow Measurement
AME 77103 Geometric & Physical Optics
AME 77104 Aeroacoustics: Theory & Comp
AME 90936 Computational Fluid Mechanics
AME 90937 Hydrodynamic Stability

Bioengineering
*AME 50548 Biofabrication (to be renumbered as 60000)
*AME 50571 Biomaterials (to be renumbered as 60000)
*AME 50572 Biomechanics (to be renumbered as 60000)
*AME 60671 Orthopaedic Biomechanics
*AME 60672 Cell Mechanics
*AME 60673 Kinematics of Human Motion
*AME 60677 Biomimetic Tissue Engineering
*AME 60678 Biomedical Imaging Modalities
*AME 60679 Nanoparticles in Biomedicine
*AME 60770 Stem Cell Engineering
AME 40470 Numerical Methods for Bioengineering (to be renumbered as 60000)

Robotics and Dynamics
*AME50551 Introduction to Robotics (to be renumbered as 60000)
*AME50562 Intermediate Controls (to be renumbered as 60000)
*AME 50650 Applied Nonlinear Analysis and Controls (to be renumbered as 60000)
*AME 60623 Analytical Dynamics
*AME XXXXX Computational Mechanism Design (course number forthcoming Spring 2019)
*EE 60550 Linear Systems

*EE 60551 Mathematical Programming

Computational Engineering
*AME 50541 Finite Element Methods (to be renumbered as 60000)
*AME 60614 Numerical Methods
*AME 60741 Computational Nonlinear Solid Mechanics
*AME 70779 Statistical Computing Methods for Scientists & Engineers
*AME 90936 Computational Fluid Mechanics

*ACMS 60212 Advanced Scientific Computing
*ACMS 60690 Numerical Analysis I
*ACMS 60790 Numerical Analysis II
*ACMS 60395 Numerical Linear Algebra
*ACMS 60650 Applied Partial Differential Equations
*CE 60140 Applied/Computational probability for engineers

Materials & Thermal Science and Manufacturing **(1 of the 3 required core courses must be an AME course)**
*AME 60624 Continuum Mechanics
*AME 60634 Intermediate Heat Transfer
*AME 60641 Advanced Mechanics of Solids
*AME 60642 Manufacturing Systems
*AME 60643 Mechanics of Sliding Surfaces
*AME 60645 Adv. Mech. Behavior of Materials
*AME 60646 Failure of Materials
*AME 60677 Biomimetic Tissue Engineering
*AME 60679 Nanoparticles in Biomedicine
*AME 60733 Solar Energy: Photovoltaic Systems
*AME 60649 Molecular Level Modeling for Engineering Applications (to be renumbered as 70000)
*AME 60637 Ionization & Ion Transport (to be renumbered as 70000)
*CBE 60547 Modern Methods in Computational Molecular Thermodynamics and Kinetics
*CBE 60561 Structure of Solids
*CBE 60577 Nanoscience and Technology
*CBE 60642 Molecular Thermodynamics
*CBE 60727 Ambient Methods of Surface Characterization
*CHEM 60435 Electrochemistry and Electrochemical Engineering
*CHEM 60610 Organometallic Chemistry
*CHEM 60618 Chemical Crystallography
*CHEM 60641 Statistical Mechanics I
*CHEM 60642 Statistical Mechanics II
*CHEM 60649 Quantum Mechanics
*EE 60548 Electromagnetic Theory
*EE 60556 Fundamentals of Semiconductor Physics
*EE 60566 Solid State Devices
*EE 60647 Alternative Energy Devices and Materials
*EE 60657 Optoelectronic Devices

*EE 60672 Vacuum and SEM Technology
*EE 67055 Introduction to Biophotonics and Biomedical Optics
*EE 80603 Transmission Electron Microscopy
*EE 87039 Quantum Optics and Nanophotonics

Appendix E.1 Qualifying Exam Timeline and Procedures

Timing

A student may take the QE during one of three triannual windows: (a) the week immediately prior to the spring semester, (b) the week immediately after spring semester finals week, or (c) the week immediately prior to the fall semester. **The exam must be completed before the beginning of the student's 4th semester.**

A typical student, entering during the fall semester will take the QE either immediately following finals week of their spring (2nd) semester *or* at the end of that first summer during the week immediately prior to the fall semester. A student entering during the spring semester will generally take the QE at the completion of the summer following their 1st semester, during the week immediately prior to the fall semester, or after their fall (2nd) semester, in the week immediately preceding the start of spring semester. The scheduling of the exam will be coordinated by the individual AME graduate student with his/her approved examination committee, and when a date/time has been selected, exam room scheduling will be coordinated with the AME Graduate Program Administrator.

Committee Makeup

QE committees consists of three AME graduate faculty (see Appendix B) configured in one of two ways:

- student's advisor, one within the broad subject area of the student's research topic, and one outside the student's research area to provide breadth of expertise[21];
- student's advisor, student's co-advisor; and one outside the student's research area to provide breadth of expertise.

Students are asked to recommend a few possible different committee members to the DGS and are encouraged to discuss possible members with their advisor. Students may also informally reach out to potential committee members prior to submitting their recommendations, but should be aware that final committee member decisions are made by the DGS in order to balance faculty workload and ensure sufficient breadth across the committee. It is important to note that the student's QE committee is independent of (and therefore may be different from) their committees at their candidacy examination or dissertation defense.

Timeline and Procedures

- *Five weeks prior to exam window*: DGS contacts eligible students and provides intent form
- *Four weeks prior to exam window:* Students intending to take the exam submit intent form, which includes recommended committee members, to Graduate Program Administrator.
- *Two weeks prior to the selected exam window*: the student must submit a 5-7 page document that demonstrates an understanding of the fundamental science underlying the content in one of two options:
    (a) ongoing research, including the motivation, methods, and results;

[21] The rule of thumb is that that outside member is someone would not be appropriate for the student's dissertation committee.

(b) literature review of subject area(s) chosen by the student's advisor, which may include key papers specified by the advisor.

The student is encouraged to discuss the document and its content with their advisor. It is also recommended that the student make their committee aware of the document's content in advance. A soft copy of this must also be submitted to the Program Administrator at the time it is delivered to the committee.

During the scheduled exam time, the student will present the content of their QE document (~20 minutes) followed by an oral exam with the committee, such that the overall length of the presentation and oral exam is no more than 60 minutes total. Questions posed to the student by the committee will focus on the student's readiness for Ph.D. research, including gaps in understanding of the fundamental science underlying the content presented. Each committee member will provide their feedback directly to the student and advisor regarding the student's readiness for Ph.D. research, which may include recommendations for research direction, further preparation, and planned academic coursework. This feedback will be both verbal at the end of the exam and in written form by each committee member. **The entire exam – presentation and examination by the committee – is closed to the public.**

Appendix E.2 Candidacy Exam Timeline and Procedures

Timing

A student may take the Candidacy Exam at any time *after* completing the Qualifying Exam and *prior to* completion of the student's 4th year (8th semester). If the student does not complete the Candidacy Exam prior to the completion of the student's 4th year, they will be placed on probation by the Graduate School, which may result in loss of financial support or a financial penalty.

Typically, a student that entered the Ph.D. program with a B.S. will complete their Candidacy Exam at the end of their 3rd year. A student that entered the Ph.D. program with a M.S. will typically complete their Candidacy Exam at the end of their 2nd year. The Candidacy Exam can be scheduled at any time but specific deadlines are defined by the Graduate School so that the exam counts as being completed in that semester. These deadlines can be found at:
https://graduateschool.nd.edu/policies-forms/academic-year-deadlines/

Committee Makeup

The Candidacy Exam is administered by committee of *at least* four members that consists of:

- the student's advisor
- three additional faculty members *or* two faculty additional faculty members and co-advisor (if applicable)

The three additional faculty members serve the role of *readers* of the student's dissertation. Unless special circumstances warrant, at least two of the three readers on the candidacy committee should be members of the AME Graduate Faculty (see Appendix B). In some cases, students have a committee of 5 or more faculty members. If a student wishes to include someone from outside of the University on their Committee, they should see the graduate program administrative assistant as it requires approval of the DGS in consultation with the Graduate Studies Committee. In general, individuals from outside the University should be on the faculty at another university or otherwise have a record of scholarly activity. Company/corporate individuals involved in a student's research may be added as additional committee members, but only after approval from the DGS.

To initiate the Candidacy Exam process, the student should consult with their advisor(s) to identify potential members of a their committee. The student should then reach out to the potential faculty directly and confirm their willingness to serve on the committee. Students' should not assume that any faculty member will agree to be on their committee without contacting them.

Timeline and Procedures

- *Initiate the process*: Complete the Ph.D. Committee Formation form with the names and signatures of the committee members. Complete the Course Approval Form with completed or projected courses and the requirements they fulfill. The forms can be found on the Department resources/forms webpage.[22] Preliminarily identify a potential exam date with committee members.
- *Three weeks (at least) prior to intended exam date*: Send written dissertation proposal to committee members for them to read.

[22] http://ame.nd.edu/resources/forms

- *One week (at least) prior to intended exam date*: Complete the Written Ph.D. Candidacy Examination Form with signatures from all committee members that have read the written dissertation proposal.
- *One week prior to intended exam date*: Send all completed forms to the Program Administrator along with the following information
    - Name and ID number (#900)
    - Date, time, and place of the exam (the Program Administrator can assist with room scheduling)
    - Advisor(s) name
    - All committee members and their department/company affiliations

During the scheduled exam time, the student will present the content of their dissertation proposal to the committee (~30-40 minutes) followed by audience questions and then an oral exam with the committee. After the examination, the student's advisor will excuse the student and call for discussion followed by a vote of committee members. The results are recorded on a Reporting Form that must be returned to the Program Administrator. Official notification of the results of the examination will be sent to the student and their advisor(s) from the Graduate School. (See Appendix I for more detailed information.) **The first portion of the exam – presentation and audience questions is open to the public; the examination by the committee is closed to the public.**

Appendix E.3 Dissertation Defense Timeline and Procedures

Timing

A student may complete and defend their dissertation *after* completing two semesters following the successful completion of the Qualifying Exam. Students must complete and defend their dissertation *prior to* completion of their student's 8th year (16th semester). If the student does not complete their dissertation and defense prior to the completion of the student's 8th year, they may be subject to dismissal by the Graduate School unless there are extenuating circumstances.

Typically, a student that entered the Ph.D. program with a B.S. will complete their Dissertation Defense at the end of their 5th year. A student that entered the Ph.D. program with a M.S. will typically complete their Dissertation Defense at the end of their 4th year. The Dissertation Defense can be scheduled at any time but specific deadlines are defined by the Graduate School so that the dissertation counts as being completed in that semester. These deadlines can be found at: https://graduateschool.nd.edu/policies-forms/academic-year-deadlines/

Committee Makeup

The Dissertation Defense is administered by committee of *at least* four members that consists of:

- the student's advisor
- three additional faculty members *or* two faculty additional faculty members and co-advisor (if applicable)

The three additional faculty members serve the role of *readers* of the student's dissertation. In nearly all cases, the dissertation committee is the same as the committee for the qualifying exam. If the student wishes to change their committee, they should contact the DGS in advance.

The makeup of the committee is described in Appendix E.2 but also repeated here. Unless special circumstances warrant, at least two of the three readers on the candidacy committee should be members of the AME Graduate Faculty (see Appendix B). In some cases, students have a committee of 5 or more faculty members. If a student wishes to include someone from outside of the University on their Committee, they should see the graduate program administrative assistant as it requires approval of the DGS in consultation with the Graduate Studies Committee. In general, individuals from outside the University should be on the faculty at another university or otherwise have a record of scholarly activity. Company/corporate individuals involved in a student's research may be added as additional committee members, but only after approval from the DGS.

Timeline and Procedures

- *Initiate the process*: Complete the Release of Ph.D. Dissertation for Distribution to the Doctoral Committee form with the signatures of the student's advisor(s). Completion of this form acknowledges that the dissertation is complete, preliminarily approved by the advisor, and ready to be distributed to the committee.
- *Four weeks (at least) prior to intended defense date*: Send written dissertation to committee members for them to read.
- *One week (at least) prior to intended defense date*: Complete the Ph.D. Dissertation Reader forms with signatures from all committee members that have read and approve the dissertation.
- *One week prior to intended exam date*: Send all completed forms to the Program Administrator along with the following information

- Name and ID number (#900)
- Date, time, and place of the defense (the Program Administrator can assist with room scheduling)
- Advisor(s) name
- All committee members and their department/company affiliations

During the scheduled defense time, the student will present the content of their dissertation to the committee (~40-60 minutes) followed by audience questions and then an oral defense with the committee. After the defense, the student's advisor will excuse the student and call for discussion followed by a vote of committee members. The results are recorded on a Reporting Form that must be returned to the Program Administrator. **The first portion of the defense – presentation and audience questions – is open to the public; the defense with the committee is closed to the public.**

APPENDIX F: 2019-2020 GRADUATE COURSE OFFERINGS[23]

Course	Title	Instructor	Semester Offered
AME 60611	Mathematical Methods I	Zabaras, Nicholas	Fall 2019
AME 60623	Analytical Dynamics	Wensing, Patrick	Fall 2019
AME 60630	Intermediate Compressible Flow	Juliano, Thomas	Fall 2019
AME 60634	Intermediate Heat Transfer	Zhang, Yanliang	Fall 2019
AME 60635	Intermediate Fluid Mechanics	Powers, Joseph	Fall 2019
AME 60641	Adv. Mechanics of Solids	Ovaert, Timothy	Fall 2019
AME 60677	Biomimetic Tissue Engineering	Niebur, Glen	Fall 2019
AME 60733	Solar Energy: Photovol Sytems	Neretina, Svetlana	Fall 2019
AME 60735	Adv. Data Analysis Tech	Gordeyev, Stanislav	Fall 2019
AME70779	Stat Comp Method for Sci & Engr	Taflanidis,Alexandros	Fall 2019
AME 90620	Advanced Continuum Mechs	Matous, Karel	Fall 2019
AME 60612	Mathematical Methods II	Chang, Chia	Spring 2020
AME 60614	Numerical Methods	MacArt, Jon	Spring 2020
AME 60624	Continuum Mechanics	Holland, Maria	Spring 2020
AME 60639	Advanced Aerodynamics	Sakaue, Hirotaka	Spring 2020
AME 60649	Molecular-Level Modeling	Luo, Tengfei	Spring 2020
AME 60654	Advanced Kinematics	Stanisic, Michael	Spring 2020
AME 60671	Orthopaedic Biomechanics	Niebur, Glen	Spring 2020
AME 60673	Kinematics of Human Motion	Schmiedeler, James	Spring 2020
AME 60679	Nanoparticles in Biomedicine	Roeder, Ryan	Spring 2020
AME 90931	Viscous Flow	Jumper, Eric	Spring 2020
AME 90991	Probabilistic Graphical Methods	Zabaras, Nicholas	Spring 2020

[23] Proposed as of August 2019. **Course offerings are subject to change** due to low enrollment or other circumstances.

APPENDIX G: MEDICAL SEPARATION FROM ACADEMIC DUTIES FOR STUDENTS IN THE GRADUATE SCHOOL

Students enrolled in the Notre Dame Graduate School who wish to temporarily interrupt their programs for medical reasons must apply to the Graduate School. Information can be found in the Forms, Policies, and Handbooks section in the Academic Code of the Graduate School: https://graduateschool.nd.edu/resources-for-current-students/

APPENDIX H: COURSE CHECKLIST FOR CANDIDACY EXAMINATIONS[24]

Student: _____ _____ ____ _____
Last Name *First Name* *MI* *NDID#*

Advisor: _____ Co-Advisor: _____
Print Name *(If applicable) Print Name*

Term Started (Semester, Year):_____ (*example: Fall, 2000*)

Date of Candidacy Exam*:_____

Instructions: Complete this form and submit to Gail Small at the time your candidacy exam is scheduled. Descriptions of the course requirements can be found in the Graduate Studies Handbook.

Math Courses

	Course #	Term & Year*	Grade
Fundamentals			
Specialization			

Pillar area: _____

Pillar core courses (3):

Course #	Term & Year*	Grade

Techniques Course

Course #	Term & Year*	Grade

Breadth Courses† (2)

Course #	Term & Year*	Grade

Elective Courses (2)

Course #	Term and Year*	Grade

* Enter planned completion date if not yet taken. Note that any proposed courses listed on this form must be taken prior to graduation, or an amended form must be submitted and approved by the director of graduate studies.

† Must be outside of pillar area course list.

Student:_____ Date: _____
Signature

Advisor:_____ Date: _____
Signature

Co-Advisor:_____ Date: _____
(If applicable) Signature

Approval:_____ Date: _____
Director of Graduate Studies Signature

[24] **A fillable/savable version of this form can be downloaded at: http://ame.nd.edu/resources/forms

APPENDIX I: REQUEST TO TRANSFER COURSES (REVISED 8/2019)[25]

Student: _____ _____ ____ _____
Last Name *First Name* *MI* *NDID#*

Advisor: _____ Co-Advisor: _____
Print Name *(If applicable)* *Print Name*

Instructions: Complete this form and submit to Gail Small before the completion of your first academic year of study. Attach a copy of your academic transcripts, and a syllabus for each course. If you believe the course satisfies the mathematics, numerical methods or out-of-department requirements, indicate so in the *Requirement* column.

*Note: Form data is savable using Reader 8.0 or higher.

Is this transfer request for credits from a previously completed and awarded master's degree? Yes No

Institution	Course #	Course Name	Term/Year	Grade	Requirement

Student: _____ Date: _____
Signature

Advisor: _____ Date: _____
Signature

Co-Advisor: _____ Date: _____
(If applicable) Signature

Approval: _____ Date: _____
Director of Graduate Studies Signature

Additional Comments:

[25] **A fillable/savable version of this form can be downloaded at: http://ame.nd.edu/resources/forms

APPENDIX J: DEPARTMENT CALENDAR

Fall Semester 2019	
AME New graduate student orientation	August 19
First day of class	August 27
Last day for course changes	September 3
Last day for course discontinuance	November 1
Department deadline to submit dissertation to readers*	October 28
Preliminary Format Check (mandatory)	November 04
Last day for Ph.D. dissertation defense for (January Graduation)	November 25
Last day for Master's thesis defense	November 25
Submission of completed theses/dissertations to Graduate School	December 2
Spring Semester 2020	
Qualifying examination (first-year students)	January 06-10
First day of class	January 14
Last day for course changes	January 21
Last day for course discontinuance	March 20
Department deadline to submit dissertation to readers*	March 02
Preliminary Format Check (mandatory)	March 02
Last day for Ph.D. dissertation defense (May graduation)	March 30
Last day for Master's thesis defense	March 30
Submission of completed theses/dissertations to Graduate School	April 06
Summer 2020	
Qualifying examination (first-year students)	May 11-15
GRED 60501 (required for first year students)	See http://kaneb.nd.edu/
Department deadline to submit dissertation to readers*	June 01
Preliminary Format Check (mandatory)	June 08
Last day for Ph.D. dissertation defense (August graduation)	June 29
Last day for Master's thesis defense	June 29
Submission of completed theses/dissertations to Graduate School	July 06

*PhD committee members must be allowed up to a maximum of 3 weeks to read and approve the dissertation before the oral defense can be scheduled. Once all signed readers reports have been received, the dissertation can officially be defended.