

GRADUATE STUDY POLICIES AND PROCEDURES

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The following material has been prepared in order to aid students in planning their graduate study program in Aerospace and Ocean Engineering. Policies concerning admissions, degree requirements, examinations, etc., are included. The information contained herein is intended to supplement the information given in the Graduate Policies and Procedures and Course Catalog obtainable on the Graduate School web site. It is the student's responsibility to follow the policies and procedures presented in the Policies and Procedures and Catalog, and in this document. For an AOE graduate student, the degree requirements are defined by the *AOE Graduate Study Policies and Procedures* that are in effect at the start of the academic year in which the student files the Plan of Study.

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I. ADMISSION REQUIREMENTS AND PROCEDURES

Applications to the AOE Department's graduate programs are reviewed by the AOE faculty, who evaluate each applicant's suitability for the AOE graduate program, including an assessment of the applicant's ability to carry out scholarly work at the graduate level. A non-refundable application fee (\$65) is required of all applicants at the time the application is submitted. Admissions recommendations are made to the Graduate School on the advice of the AOE Graduate Committee. Admission to the AOE graduate program is granted by the Virginia Tech Graduate School upon review of the Graduate Committee's recommendations. More information regarding the online application can be accessed at the following link: <http://graduateschool.vt.edu/applying>.

The deadline for applications to begin graduate study in the Fall semester is December 30th and the deadline for applications to begin graduate study in the Spring semester is September 1st. International applicants must have a completed application on file with the AOE department by these dates in order to be considered for admission. Domestic applicants should adhere to these deadlines as well in order to ensure full consideration for financial assistance.

All applications are reviewed and evaluated based on the applicant's past academic performance, research and work experience, recommendation letters, and test scores. Applicants are ranked accordingly and recommendations are periodically made concerning which applicants should be offered acceptance into the graduate program and, in some cases, assistantships. Acceptances and assistantship offers are based on many factors in addition to those mentioned previously. These additional factors include departmental needs in the indicated areas of interest and availability of research funds. The application review process can range from a few weeks to several months.

Virginia Tech does not discriminate against employees, students or applicants on the basis of race, color, sex, sexual orientation, disability, age, veteran status, national origin, religion, or political affiliation. The University is subject to titles VI and VII of the Civil Rights Act of 1964, Title IX of the Education Amendments of 1972, Sections 503 and 504 of the Rehabilitation Act of 1973, the Age Discrimination in Employment Act, the Vietnam Era Veteran Readjustment Assistance Act of 1974, Federal Executive Order 11246, Governor Allen's State Executive Order

Number Two, and all other rules and regulations that are applicable. Anyone having questions concerning any of those regulations should contact the Equal Opportunity/Affirmative Action Office. The *minimum requirements* for admission established by the AOE Department are listed below (note that meeting these does not guarantee admission):

1. The applicant should have a Bachelor's degree, usually in Engineering, Mathematics, or Physics, from an accredited institution.
2. The applicant should provide evidence which shows genuine promise of success in graduate study such as a good academic record, especially in the Junior and Senior years, and satisfactory letters of recommendation. For regular status, a minimum average of B (3.0/4.0) or better is required. Averages below this value may be considered, on an individual basis, for provisional status, when there is additional evidence of achievement, such as work experience.
3. Scores of the General (Verbal, Quantitative, and Analytic) portion of the Graduate Record Examination (GRE) must be submitted for all applicants. More information can be found at the following link: <http://www.ets.org>.
4. All foreign applicants who have not earned a degree from an accredited English speaking institution are required to take the Test of English as a Foreign Language (TOEFL). More information can be found at the following link: <http://www.ets.org>.
5. At the beginning of the Fall Semester, the AOE Department holds an orientation for new graduate students. This orientation provides an opportunity for new students to meet each other and the graduate program personnel. The orientation meeting also covers establishing a Plan of Study, as well as some administrative and logistical details.

II. FINANCIAL AID

A number of Graduate Assistantships and Fellowships are available. To be eligible for aid, an applicant should have at least a B (3.0/4.0) average for the last 60 hours of study. A student must maintain at least a 3.0 average (GPA) each semester at Virginia Tech to remain eligible for an Assistantship.

A. Graduate Assistantships

1. Graduate Assistantships are the most common form of financial assistance. For this type of assistance, the graduate student devotes a minimum of twenty hours per week to assigned duties, primarily research or instructional assistance, other than course work. Assistantships are targeted towards Ph.D. students and, to a lesser degree, thesis Masters students. Students on a Graduate Research Assistantship (GRA) will devote twenty hours per week towards research, while students on a Graduate Teaching Assistantship (GTA) will devote twenty hours per week towards instructional assistance (e.g., holding office hours, teaching a recitation section, creating homework and test problems, and grading assignments).
2. A student on a Graduate Assistantship must carry a minimum of 12 hours of course work and research hours per semester. Students may not register for more than 18 hours of coursework and research hours in a semester without prior approval from the Dean of the Graduate School. Normally, students will register for 12 hours of course work and research (including 3 or more hours of research) plus the 1 hour Graduate Seminar. Registration during summer sessions is not required unless the degree program is to be completed during a summer session.
3. Graduate Assistantship stipends typically start at a Step 8 on the stipend table for new Masters level students and Step 12 for new Ph.D. students. The Graduate Student Stipend table can be found at the following link: <http://graduateschool.vt.edu/financial/assistantships#Graduate%20Stipends>. Increases in a stipend depend on a student's experience, academic record, and past performance. Payment is on or near the 1st and 16th of each month, with the first payment of the academic year being on or near September 1.

4. All students with Graduate Assistantships have their tuition paid by the department or from a research grant or contract. Hence, students with Graduate Assistantships effectively have a tuition waiver. However, students are responsible for paying all comprehensive fees.
5. Students with Graduate Research Assistantships are evaluated at the end of each semester by the faculty Advisor for whom they are doing research. A student performing in an unsatisfactory manner will be apprised of the deficiency and instructed on how to improve performance. An additional unsatisfactory review could result in temporary or permanent loss of the Graduate Assistantship.
6. Students with Graduate Teaching Assistantships are evaluated at the end of each semester by the faculty member for whom they are providing instructional assistance. A student performing in an unsatisfactory manner will be apprised of the deficiency and instructed on how to improve performance. An additional unsatisfactory review could result in temporary or permanent loss of the Graduate Assistantship.

B. Supplemental Fellowships

Fellowships are available to supplement the Graduate Assistantship stipends of exceptionally well qualified students. Recipients of these fellowships are reviewed after each semester with regard to their academic and research progress and performance. A minimum GPA of 3.2 is required to retain a fellowship.

C. Other Fellowships

The AOE Department does not currently award Fellowships other than as supplements to Graduate Assistantships. However, all graduate students are encouraged to apply for external support, when eligible and qualified. Information about such opportunities is posted on both the AOE and Graduate School web sites.

III. ESTABLISHING A PLAN OF STUDY

Each graduate student establishes an Advisory Committee which guides the student in defining his or her program of study, advises the student concerning specific degree requirements, and evaluates the student's progress providing constructive feedback. The Chairperson of the Advisory Committee is the student's Advisor.

A. Areas of Specialization for Graduate Degrees

The M.S., M.Eng., and Ph.D. degrees are offered in Aerospace Engineering. The M.S. degree is offered in Ocean Engineering. An Ocean Engineering option is offered under the Aerospace Engineering Ph.D. program. The areas of specialization are described below.

1. Aero-Hydrodynamics (M.S., M.Eng., and Ph.D. in Aerospace Engineering).

This area is concerned with the determination of forces and moments caused by the motion of an aerospace or ocean vehicle through a liquid or gaseous medium, and with the nature of the flow field around the vehicle and in its wake. This determination ranges from very low subsonic speeds through the speed of sound (transonic) to supersonic and hypersonic speeds. Both inviscid and viscous flow phenomena are significant. In addition, the study of internal flow fields associated with propulsion is a subset of this area.

2. Dynamics and Control (M.S., M.Eng., and Ph.D. in Aerospace Engineering).

The area of dynamics involves dynamic modeling and analysis for space, atmospheric, and ocean vehicles. The area of control involves the development and application of methods for vehicle guidance, navigation, and control.

3. **Structures and Structural Dynamics (M.S., M.Eng., and Ph.D. in Aerospace Engineering).**

This area involves development and application of methods for design and evaluation of aerospace and ocean structures. Principal subjects of study are finite element analysis, modal vibration analysis, the mechanics of fiber-reinforced (composite) structures, structural stability, the interaction of a flexible structure with its surrounding environment, and with the control systems which guide and stabilize it.

4. **Ocean Engineering (M.S. or as an option under a Ph.D. in Aerospace Engineering).**

This area of engineering deals with all hardware systems (including ships, offshore petroleum and mineral exploration and production systems, naval systems, instrumentation associated with environmental and pollution data, detection and collection systems) that function on or within the sea.

5. **Applied Physics (Ph.D. in Aerospace Engineering only).**

This area is concerned with the application of classical and modern physics to the development of advanced aerospace instrumentation and vehicles. This is an interdisciplinary program. In addition to traditional subjects in aerospace engineering, students in this program also study subjects in applied physics, plasma physics, and electrical engineering.

6. **Space Engineering (Ph.D. in Aerospace Engineering only).**

This area is concerned with the multidisciplinary application of Aerospace, Electrical, Mechanical, and Systems Engineering (among others) to the development of advanced space instrumentation, vehicles, constellations, and space exploration systems. In addition, this program includes subjects in space physics.

7. **Applied Math (Ph.D. in Aerospace Engineering only).**

This subject area involves the use of analytical and numerical mathematics to treat problems in the aerospace and ocean fields. Typical areas of study include partial differential equations, numerical analysis and control theory.

B. Selection of Advisor

1. On the supplemental page of the application for admission, students should specify their principal area of interest from the seven areas of specialization described in Section III.A. and indicate the names of AOE faculty members with whom they are interested in working.
2. For students entering on a Graduate Research Assistantship, the faculty member funding the research will generally serve as the student's Advisor.
3. Students entering on a Graduate Teaching Assistantship, or those entering without funding, have until the end of their first semester enrolled to mutually select an advisor. As part of this selection process, the student is expected to proactively seek to attend research meeting of prospective Advisors with mutual research interests. Furthermore, the student should seek to actively engage in research whenever possible.
4. The Advisor will help establish the student's Plan of Study and, for students pursuing a thesis or dissertation, will serve as the student's research mentor. A student with a Graduate Research Assistantship who, in the course of the graduate program, selects a different Advisor must renegotiate the Assistantship agreement with the new Advisor, in communication with the Graduate Program Coordinator. Such changes are made at the end of a semester.
5. All full time faculty members in the AOE department are eligible to be M.S., M.Eng., and Ph.D. candidate Advisors. Faculty members from other departments may serve as Advisors if approved by the Department Head and the AOE Graduate Committee as AOE Affiliate Faculty. Any faculty member from another department must be eligible to advise M.S. or Ph.D. students in their own department.

C. Selection of Advisory Committee

1. The student, in consultation with the Advisor, will identify additional candidates to serve on the Advisory Committee and invite them to serve.
2. In special cases, which may occur when students are planning to do their research in absentia, highly qualified persons who are not Virginia Tech faculty members may serve as Advisory Committee members or co-Advisor (co-Chairperson), with approval of the Dean of the Graduate School and the Department Head. These external members may not constitute more than one-third of the total Advisory Committee membership and they may not serve as the sole Advisor (Chairperson).
3. Committees for the M.S. and M.Eng., must satisfy the following requirements in addition to those above:
 - a. The Advisory Committee must consist of at least three members, at least two of whom must be on the AOE faculty.
 - b. The Advisor (Chairperson) must be a member of the resident Virginia Tech faculty, but is not required to be a member of the AOE Faculty.
4. Committees for the Ph.D. must satisfy the following requirements in addition to those in (2) above:
 - a. The Advisory Committee must consist of at least four members, at least three of whom must be on the AOE faculty.
 - b. The Advisor (Chairperson) must be a member of the resident Virginia Tech faculty, and ordinarily is a member of the AOE faculty. In special cases with the approval of the Department Head, a member of the Virginia Tech faculty outside the AOE Department may serve as Advisor.
 - i. In the Applied Physics, Space Engineering, or Applied Mathematics areas, the Advisory Committee must include at least one member from a relevant external department.

D. Duties of the Advisory Committee

The Advisory Committee's duties are to aid the student in establishing a Plan of Study, to approve the Plan of Study, to provide research guidance to the student as appropriate to the degree being sought, and to act as the Final Examination Committee. In signing the Plan of Study, an Advisory Committee member commits to serve in each of these capacities. A faculty member is obligated to participate in all scheduled meetings of the Advisory Committee, to help support the research efforts of the student, and to support all activities specified below in Section V.

1. The signatures of faculty members on a student's Plan of Study constitute approval of the program by the faculty members and the indication that they are willing to serve on the student's Advisory Committee. It is the student's responsibility, however, to insure that the program satisfies all requirements. Any waivers of the requirements must be described in the Plan of Study and must be fully approved (see item E.2 below).
2. Every member of the Advisory Committee must approve any revision of the student's Plan of Study.

E. Plan of Study

The Plan of Study determines the student's course activities. It is important to establish a Plan of Study as early as possible to assure that, from the beginning of graduate study, all courses fit into a coherent program. Every course listed within a given Plan of Study should make a contribution to the student's overall educational objective.

1. Students should prepare their Plan of Study, in consultation with their Advisors and Advisory Committees. Forms for the Plan of Study can be obtained from AOE Graduate Program Coordinator or from the AOE web site.

2. If an entering student's background is deficient in a technical area which the Advisory Committee considers essential for the student's program of study, the deficiency must be addressed in a manner which satisfies the Advisory Committee. This process may include formal course work to appear on the Plan of Study, remedial course work that does not appear on the Plan of Study, or informal study and evaluation by the Advisory Committee.
3. All course work which appears on the Plan of Study must satisfy the following requirements when the Plan of Study is submitted and at the time of the Final Examination:
 - a. Completed courses on the Plan of Study must have been taken within the previous five years.
 - b. Courses yet to be taken must be completed within five years.
 - c. In some cases, courses that do not satisfy these time requirements may be included on the Plan of Study through the Graduate School's Course Justification process.
4. The original Plan of Study and any subsequent revisions must be approved in the following sequence:
 - a. Advisor
 - b. Advisory Committee
 - c. AOE Graduate Program Director or Department Head
 - d. AOE Graduate Program Coordinator
 - e. Virginia Tech Graduate School
5. After all appropriate signatures (and Virginia Tech Identification Numbers for members of the Advisory Committee outside of the AOE Department) are obtained, the Plan of Study form is submitted to the AOE Graduate Program Coordinator who will submit it to the Graduate School. The Plan of Study must be submitted to the AOE Graduate Coordinator no later than the end of the second (2nd) academic semester for M.S. and M.Eng. students and no later than the end of the third (3rd) academic semester for Ph.D. students.

IV. DEGREE REQUIREMENTS

Only 5000-6000 level courses (and up to six hours of 4000 level course work) are acceptable for the Plan of Study. No courses required for the undergraduate AOE degree may be taken by AOE graduate students for graduate credit. Courses in other departments that are judged to duplicate AOE courses to a high degree may not be used towards AOE degrees.

A. Master of Science Requirements: Thesis and (Non-Thesis)

1. A minimum of 30 credit hours is required.
 - For thesis students, up to 10 credit hours may be allotted for Research and Thesis (AOE 5994).
 - For non-thesis students, up to 6 credit hours may be allotted for Project and Report (AOE 5904).
2. A minimum of 12 credit hours (15 for non-thesis) of graded course work numbered 5000 and higher must be included in the Plan of Study. These credit hours do not include the AOE Seminar (AOE 5944), Research and Thesis (AOE 5994) hours, or Project and Report (AOE 5904) hours.
3. A maximum of 6 credit hours (9 for non-thesis) of 5974 and 5984 is allowed.
4. A maximum of 6 credit hours of approved 4000 level course work is allowed.
5. Up to 50% of the courses on the Plan of Study may be transferred from a graduate program at another institution, subject to the approval of the Advisory Committee. Substitution of a transferred course for a

specific required course is subject to the approval of the Graduate Program Director or a designee, usually the responsible instructor. Each transferred course must have a grade of B (3.0/4.0) or better.

6. All Aerospace Engineering M.S. candidates are required to take:

- AOE 5104, Advanced Aero and Hydrodynamics;
- AOE 5024, Vehicle Structures;
- AOE 5204, Vehicle Dynamics and Control; and
- AOE 4404, Applied Numerical Methods.

The following additional required courses pertain to the three areas of specialization.

Aero-Hydrodynamics: Thesis (non-thesis) students must take 9 (18) credit hours of approved electives.

- Electives for thesis students are determined in consultation with the Advisory Committee Chair.
- Non-thesis aero-hydrodynamics students must take two of the following three courses:
 - i. AOE 5114, High Speed Aerodynamics;
 - ii. AOE 5135, Vehicle Propulsion; or
 - iii. AOE 5144, Boundary Layer Theory and Heat Transfer.

Dynamics and Control: Thesis (non-thesis) students must take 9 (18) credit hours of approved electives.

- Electives for thesis students are determined in consultation with the Advisory Committee Chair.
- Non-thesis dynamics and control students must take two of the following three courses:
 - i. AOE 5774, Nonlinear Systems Theory;
 - ii. AOE 6744, Linear Control Theory*; or
 - iii. AOE 5234, Orbital Mechanics.

*It is strongly recommended that students who wish to take AOE 6744, Linear Control Theory first take AOE 5744, Linear Systems Theory or an equivalent course on linear, time-varying systems.

Space Engineering: Thesis (non-thesis) students must take 9 (18) hours of approved electives.

- AOE 5234, Orbital Mechanics (may replace AOE 5104, Advanced Aero and Hydrodynamics; or AOE 5024, Vehicle Structures as one of the required AE courses)
- Electives for thesis students are determined in consultation with the Advisory Committee Chair.
- Non-thesis space engineering students must take two of the following courses:
 - i. AOE 5774, Nonlinear Systems Theory;
 - ii. AOE 6744, Linear Control Theory*;

- iii. AOE 5034, Vehicle Structural Dynamics;
- iv. AOE 5174, Introduction to Space Plasmas;
- v. AOE 5135, Vehicle Propulsion;
- vi. AOE 5xxx, Spacecraft Propulsion;
- vii. AOE 5xxx, Ocean Remote Sensing;
- viii. ECE 5104G, Microwave and RF Engineering;
- ix. ECE 5105, Electromagnetic Waves;
- x. ECE 5106, Electromagnetic Waves;
- xi. ECE 5164, Introduction to Space Science I: The Solar Wind and Magnetosphere;
- xii. ECE 5194 Remote Sensing: Principles and Techniques;
- xiii. ECE 5604, Computer-Aided Design and Analysis of Communication Systems;
- xiv. ECE 5655, Communication System Design;
- xv. ECE 6115, Antenna Theory and Design I;
- xvi. ESM 5734, Introduction to the Finite Element Method;
- xvii. ESM 6314, Advanced Dynamics; or
- xviii. PHYS 5405, Classical Electromagnetism.

*It is strongly recommended that students who wish to take AOE 6744, Linear Control Theory first take AOE 5744, Linear Systems Theory or an equivalent course on linear, time-varying systems.

Structures and Structural Dynamics: Thesis (non-thesis) students must take 9 (18) hours of approved electives.

- Electives for thesis students are determined in consultation with the Advisory Committee Chair.
- Non-thesis structures and structural dynamics students must take the following two courses:
 - i. AOE 5034, Vehicle Structural Dynamics and
 - ii. MATH 4574, Vector and Complex Analysis for Engineers.

7. All Ocean Engineering M.S. candidates are required to take:

- a. AOE 5104, Advanced Aero-Hydrodynamics;
- b. AOE 5334, Advanced Ship Dynamics;
- c. AOE 4404, Numerical Methods; and
- d. AOE 5074, Advanced Ship Structural Analysis*.

*If AOE 4274, Computer-Based Design of Ocean Structures has already been taken, then one of the following two courses must be substituted: AOE 5024, Vehicle Structures; or AOE 5374, Rationally-Based Design of Ocean Structures.

In addition, thesis (non-thesis) students must take 9 (18) hours of approved electives, and non-thesis students must take 6 units of “Project and Report” or complete a 6 unit Capstone Naval Ship Design project (AOE 5315 and AOE 5316).

- Electives for thesis students are determined in consultation with the Advisory Committee Chair.
 - Non-thesis ocean engineering students must take two of the following courses:
 - i. AOE 5034, Mechanical and Structural Vibrations;
 - ii. AOE 5084, Submarine Design;
 - iii. AOE 5304, Advanced Naval Architecture;
 - iv. AOE 5374, Rationally-Based Design of Ocean Structures;
 - v. AOE 5144, Boundary Layer Theory and Heat Transfer;
 - vi. AOE 5454, Advanced Aerospace and Ocean Engineering Instrumentation;
 - vii. AOE 4024, An Introduction to the Finite Element Method;
 - viii. AOE 5444G, Advanced Dynamics of High-Speed Craft;
 - ix. AOE 5324, Principles of Naval Engineering
 - x. AOE 5314, Naval and Marine Engineering System Design;
 - xi. AOE 5434G, Advanced Introduction to Computational Fluid Dynamics; or
 - xii. AOE 6145, Computational Fluid Dynamics.
8. If a student has previously taken any of the required courses listed above or equivalent, while a Virginia Tech undergraduate or a student elsewhere, that course must be replaced with another course approved by the Advisory Committee. A student will not be allowed to repeat a Virginia Tech course (or an equivalent course from another institution) for a grade. A required AOE course can only be replaced with another AOE course.

B. Master of Engineering Requirements

1. The M. Engr. degree is a non-thesis degree. However, each candidate is required to prepare a paper, the subject and outline of which must be approved by the student's Advisor and Advisory Committee. The purpose of this paper is to develop and demonstrate the student's ability to plan and carry out projects or problems relating to engineering practice. This project is carried out under the auspices of a special project (AOE 5904, Project and Report).
2. A minimum of 30 credit hours is required, of which 3-6 credit hours must be allotted for AOE 5904.
3. A minimum of 15 credit hours (including 5974 and 5984) of graded course work numbered 5000 and higher must be included in the Plan of Study.
4. A maximum of 6 credit hours of approved 4000 level course work is allowed.
5. A maximum of 9 credit hours of 5974 and 5984 is allowed.
6. Up to 50% of the courses on the Plan of Study may be transferred and are subject to approval of the Advisory Committee. Substitution of a transferred course for a specific required course is subject to the approval of the Graduate Program Director or a designee, usually the responsible instructor. Each transferred course must have a grade of B (3.0/4.0) or better.
7. A minimum of one approved math course is required.
8. All M. Engr. candidates are required to take:
 - a. AOE 4404, Applied Numerical Methods;
 - b. AOE 5104, Advanced Aero-Hydrodynamics;
 - c. AOE 5024, Vehicle Structures;
 - d. AOE 5204, Vehicle Dynamics and Control; and
 - e. One additional AOE course. If a student has previously taken, while an undergraduate or student elsewhere, any of the specific required AOE courses above or equivalent, that course must be replaced with another AOE course acceptable to the Advisory Committee. A student will not be allowed to repeat a course from Virginia Tech or one that is equivalent from another institution for a grade.
9. The project described in requirement (1) may be carried out in conjunction with other students in the same program (e.g., a design project with several students of varied interests).

C. Master of Science or Master of Engineering Requirements (AOE, Systems Option).

The AOE Department, in conjunction with other interested departments in the College of Engineering, e.g. Industrial and Systems Engineering, offers an interdisciplinary degree in Systems Engineering. The requirements for the degree are essentially the same as those outlined above with the exception of the interdisciplinary aspect of the curriculum, which will be prescribed by the student's Advisory committee consisting of faculty from the AOE Department and the other relevant departments.

D. Doctor of Philosophy Requirements (beyond B.S.)

1. A minimum of 90 credit hours beyond the B.S. degree are required.
2. A minimum of 30 hours of Research and Dissertation (AOE 7994) must be included on the Plan of Study.

3. A minimum of 27 credit hours of graded course work numbered 5000 or above must be included.
4. A maximum of 18 credit hours of Independent Study (5974) and Special Study (5984) may be included.
5. A maximum of 4 credit hours may be seminars (unstructured courses), *not* including AOE Graduate Seminar (AOE 5944).
6. A minimum of two consecutive semesters of full time enrollment must be spent in residence at the Blacksburg campus (or with prior approval at some designated off-campus graduate center). At least 15 credit hours of course work (not including AOE 7994) must be earned while in residence.
7. Transfer credit hours may not exceed 50% of graded graduate level credit hours numbered 5000 or higher needed to satisfy the requirements for a Ph.D. (as described below) and are subject to the approval of the Advisory Committee. Substitution of a transferred course for a specific required course is subject to the approval of the Graduate Program Director or a designee, usually the responsible instructor. Each transferred course must have a grade of B (3.0/4.0) or better.
8. All Ph.D. candidates are required to complete selected courses. Some of the courses are required prior to taking the Preliminary Written Examination and the remaining courses are required prior to completion of the degree. The following additional courses are required according to the area of specialization:
 - a. Aero-Hydrodynamics
 - i. Before taking the Preliminary Written Examination:
 - AOE 4404, Applied Numerical Methods;
 - AOE 5104, Advanced Aero and Hydrodynamics;
 - AOE 5024, Vehicle Structures;
 - AOE 5204, Vehicle Dynamics and Control;
 - AOE 5114, High Speed Aerodynamics;
 - AOE 5135, Vehicle Propulsion; and
 - AOE 5144, Boundary Layer and Heat Transfer.
 - ii. Before taking the Final Examination:
 - AOE 5454, Advanced Aerospace and Ocean Engineering Instrumentation;
 - One of the following courses: AOE 5434G, Advanced Introduction to Computational Fluid Dynamics; AOE 6145, Computational Fluid Dynamics; or AOE 6434, Computational Fluid Dynamics and Heat Transfer;
 - AOE 6114, Transonic Aerodynamics; and
 - Any two of the following courses: AOE 6124, Hypersonic Aerodynamics; AOE 6154, Turbulent Shear Flow; AOE 6174, Computational Plasma Dynamics; and AOE 6444, Verification and Validation in Scientific Computing.

b. Dynamics and Control

i. Before taking the Preliminary Written Examination:

- AOE 4404, Applied Numerical Methods;
- AOE 5104, Advanced Aero and Hydrodynamics;
- AOE 5024, Vehicle Structures;
- AOE 5204, Vehicle Dynamics and Control; and
- Any two from AOE 5774, Nonlinear Systems Theory; AOE 6744, Linear Control Theory*; or AOE 5234, Orbital Mechanics.

*It is strongly recommended that students first take AOE 5744, Linear Systems Theory or an equivalent course on linear, time-varying systems.

ii. Before taking the Final Examination, courses determined in consultation with the Advisory Committee.

c. Ocean Engineering

i. Before taking the Preliminary Written Examination:

- AOE 4404, Applied Numerical Methods;
- AOE 5104, Advanced Aero and Hydrodynamics;
- AOE 5074, Advanced Ship Structural Analysis*; and
- AOE 5334, Advanced Ship Dynamics.

*If AOE 4274, Computer-Based Design of Ocean Structures has already been taken, then one of the following two courses must be substituted: AOE 5024, Vehicle Structures or AOE 5374, Rationally-Based Design of Ocean Structures.

ii. Plus any two of the following:

- AOE 5144, Boundary Layer and Heat Transfer;
- AOE 4024, An Introduction to the Finite Element Method;
- ESM 5734, Introduction to the Finite Element Method;
- AOE 5034, Vehicle Structural Dynamics;
- ESM 5314, Intermediate Dynamics;
- AOE 5744, Linear Systems Theory;
- MATH 5425, Applied Partial Differential Equations;
- MATH 5474, Finite Difference Methods for Partial Differential Equations;

- AOE 5324 Principles of Naval Engineering;
 - AOE 5314 Naval and Marine Engineering System Design;
 - AOE 5434G, Advanced Introduction to Computational Fluid Dynamics; and
 - AOE 5444G, Advanced Dynamics of High-Speed Marine Craft.
- iii. Before taking the Final Examination, take two of the following courses:
- Courses in group (ii) not taken prior to the Preliminary Written Examination;
 - AOE 5374, Rationally-Based Design of Ocean Structures;
 - AOE 5454, Advanced AOE Instrumentation;
 - AOE 6145, Computational Fluid Dynamics;
 - AOE 5064, Structural Optimization;
 - ESM 6314, Advanced Dynamics; and
 - AOE 6434, Computational Fluid Dynamics and Heat Transfer.

*It is strongly recommended that students who wish to take AOE 5314, Naval Ship System Design, first take AOE 4264, Principles of Naval Engineering

d. Structures and Structural Dynamics

- i. Before taking the Preliminary Written Examination:
- AOE 4404, Applied Numerical Methods;
 - AOE 5104, Advanced Aero and Hydrodynamics;
 - AOE 5024, Vehicle Structures;
 - AOE 5204, Vehicle Dynamics and Control;
 - AOE 4054, Stability of Structures or AOE 5054, Elastic Stability; and
 - AOE/ESM 5034, Mechanical and Structural Vibrations.
- ii. Before taking the Final Examination, any two of the following courses:
- AOE 5054, Elastic Stability;
 - AOE 5064, Structural Optimization;
 - AOE 5074, Advanced Ship Structural Analysis*; and
 - AOE 6024, Aeroelasticity.

* If AOE 4274: Computer-Based Design of Ocean Structures has already been

taken, then one of the following two courses must be substituted: AOE 5024, Vehicle Structures or AOE 5374, Rationally-Based Design of Ocean Structures.

e. Applied Physics

i. Before taking the Preliminary Written Examination:

- AOE 4404 Numerical Methods
- One from ECE 5105 (Electromagnetic Waves), AOE/ECE 5174 (Introduction to Space Plasmas), AOE5135 (Vehicle Propulsion)
- One graduate level course in mathematics with approval from the Advisory Committee
- Three graduate or undergraduate courses in AOE, Electrical and Computer Engineering, Computer Science, Physics, or Mechanical Engineering as determined by Advisory Committee with a maximum of one undergraduate (4000-level) course.

ii. Before taking the Final Examination:

- Any two from AOE 5024, Vehicle Structures; AOE 5104, Advanced Aero and Hydrodynamics; or AOE 5204, Vehicle Dynamics and Control; and
- Courses determined in consultation with the Advisory Committee.

f. Space Engineering

i. Before taking the Preliminary Written Examination:

- AOE 4404, Applied Numerical Methods;
- AOE 5204, Vehicle Dynamics and Control;
- AOE 5234, Orbital Mechanics;
- Any two of the following courses:
 - AOE 5034, Vehicle Structural Dynamics; ○ AOE 5174, Introduction to Space Plasmas;
 - AOE 5136, Vehicle Propulsion;
 - AOE 5xxx, Spacecraft Propulsion;
 - AOE 5xxx, Ocean Remote Sensing;
 - ECE 5104G, Microwave and RF Engineering;
 - ECE 5105, Electromagnetic Waves;
 - ECE 5106, Electromagnetic Waves;
 - ECE 5164, Introduction to Space Science I: The Solar Wind and Magnetosphere;
 - ECE 5194 Remote Sensing: Principles and Techniques;
 - ECE 5604, Computer-Aided Design and Analysis of Communication Systems;
 - ECE 5655, Communication System Design;
 - ECE 6115, Antenna Theory and Design I;
 - ESM 5734, Introduction to the Finite Element Method;

- ESM 6314, Advanced Dynamics;
 - PHYS 5405, Classical Electromagnetism
 - ii. Before taking the Final Examination:
 - One of the following two courses:
 - AOE 5024, Vehicle Structures;
 - AOE 5104, Advanced Aero and Hydrodynamics; and
 - Courses determined in consultation with the Advisory Committee.
 - g. Applied Mathematics
 - i. Before taking the Preliminary Written Examination:
 - AOE 4404, Applied Numerical Methods;
 - Two from AOE 5024, Vehicle Structures; AOE 5104, Advanced Aero and Hydrodynamics; or AOE 5204, Vehicle Dynamics and Control; and
 - Four additional graduate level Math courses determined in consultation with the Advisory Committee.
 - ii. Before taking the Final Examination:
 - Courses determined in consultation with the Advisory Committee.
9. If a graduate student has previously taken, while an undergraduate or a student elsewhere, any of the required courses listed above or equivalent, that course must be replaced with another course acceptable to the Advisory Committee. A student will not be allowed to repeat a course from Virginia Tech or one that is equivalent from another institution for a grade.
 10. Students are required to repeat any courses on the Plan of Study for which a grade of “C-” or below has been earned. Transfer credits must have been earned while in good standing in graduate status, must have been graduate courses (numbered 5000 or higher, or equivalent) at the institution where the courses were taken, and must show a grade of “B” or better. Courses that are double-counted for both an undergraduate and graduate degree for students in Virginia Tech’s Undergraduate/Graduate Degree Program are subject to the grade requirements for transfer courses.
 11. A person who graduates from this department with a Ph.D. in aerospace engineering is expected to have a broad understanding of the field. The student satisfies this requirement by completing each of the introductory graduate courses in aerodynamics (AOE 5104), dynamics and control (AOE 5204 or AOE 5334), structures (AOE 5024 or AOE 5074), and numerical methods (AOE 4404) with a grade of B or better. That grade will be considered sufficient evidence of knowledge in these areas. Transfer credits for these courses are approved by including them in a properly formulated Plan of Study approved by the student’s Advisory committee. For students in the Applied Physics, Space Engineering, or Applied Mathematics track, these requirements apply to the courses above which appear on the Plan of Study.
 12. If a student obtains less than a B in the introductory courses listed in Item 3 above, then that student must repeat the course, either formally (grade less than C-) or informally (grade equal or greater than C- and less than a B) and receive a grade of B or better in the course. In the case of an informal retake, the instructor will write a letter to the students file indicating the achievement of a grade of B or better. If this requirement is not completed at the time of the preliminary examination, and the student passes the preliminary examination, the student will be given a conditional pass. Under these circumstances, this requirement must be satisfied within two semesters (i.e. at the first opportunity) after completing the preliminary examination.

V. THESIS, DISSERTATION AND REPORT REQUIREMENTS AND PROCEDURES

The policies and procedures given below apply to both on-campus and off-campus graduate students and are intended to aid the student in working more effectively toward a degree under the supervision of the Advisor and Advisory Committee.

A. Master of Science Thesis or Ph.D. Dissertation

1. Prospectus. Each graduate student working toward the M.S. (with thesis) or Ph.D. degree is required to submit in writing to the Advisory Committee a short research prospectus stating the subject and general objectives of the proposed degree research. The Advisory Committee will determine when it must be submitted. However, a prospective committee member may require the prospectus before agreeing to serve.
2. Progress Reports. Frequent progress reports, oral or written, must be made by the student to the Advisory Committee indicating current status, difficulties and future plans of the research. The frequency of reporting and the manner of presentation is determined by the Advisor.
3. Thesis and Dissertation Registration.
 - a. All thesis M.S. or Ph.D. students must register for thesis or dissertation credit in accordance with the amount of time devoted to thesis or dissertation research. For example, a full time research load would be 12 credit hours of thesis or dissertation credit, and would require a minimum of 40 hours per week of work devoted to research.
 - b. Students are required to register for thesis or dissertation credit in accordance with that fraction of time devoted to research, regardless of the total thesis hours accumulated.
4. Dissertation Proposal. Each Ph.D. student is required to present a dissertation proposal to the Advisory Committee at least six months prior to expected completion date although an earlier presentation is encouraged. Such a proposal shall consist of two parts:
 - a. A written document which contains a statement of the problem to be investigated, the significance of the problem, a review of previous work in the area, a discussion of the proposed approach for investigating the problem, preliminary work completed by the student, and finally an overview of work left to be completed
 - b. An oral presentation of the proposal to the Advisory Committee (and other faculty, if desired). It is intended that the written portion of the proposal should serve as a rough draft of the first few chapters of the completed dissertation and should be submitted to the Advisory Committee at least one week prior to the oral presentation. The oral presentation should be informal in nature and should encourage interaction between the student and the Advisory Committee.
5. Final Review of Thesis or Dissertation. The student must have an Advisor-approved draft copy of the thesis or dissertation in the hands of each member of the Advisory Committee at least two weeks before the scheduled Final Examination for the M.S. and Ph.D. degrees. Failure to comply with this requirement will likely delay the Final Examination.
6. Requirements for thesis and dissertation preparation can be found at the following link: <http://etd.vt.edu>.

B. Master of Engineering Report

1. The proposed topic for the project report must be approved by the Advisory Committee.

2. Periodic oral or written progress reports must be made by the student to the Advisor and Committee indicating current status and future plans of the project. The frequency of reporting and the manner of presentation is determined by the Advisor.
3. A final draft copy of the project report must be in the hands of each member of the Advisory Committee at least two weeks before the scheduled examination for the M. Engr. degree. If a student report is part of a larger report submitted by several students, the entire report must be submitted to the Advisory Committee for each student involved.
4. Requirements for report preparation are the same as those for thesis or dissertation preparation, and can be found at the following link: <http://etd.vt.edu>. The final report does not have to be turned into the Graduate School but is retained in the Aerospace and Ocean Engineering Department.

VI. EXAMINATIONS

Forms for scheduling formal examinations (Masters Final Exam, Ph.D. oral Preliminary Exam, Ph.D. Final Exam) can be found on the Graduate School's web site and must be submitted to the Graduate School at least two weeks prior to the scheduled examination. A copy of each form must also be submitted to the AOE Graduate Program Coordinator.

A. Master of Science Candidates

1. Each candidate is required to pass an oral Final Examination administered by the Advisory Committee.
 - a. For the M.S. with thesis, the requirement includes a public presentation of the thesis. That presentation is followed immediately by a closed oral examination, which is primarily, but may not be exclusively, a thesis defense.
 - b. For the M.S. without thesis, the examination is a comprehensive exam closed to the public. The format of the examination is at the discretion of the Advisory Committee.
2. On the basis of the candidate's performance in the examination (and the quality of the thesis, if appropriate), the Advisory Committee will determine whether the student has passed or failed.
 - a. A majority vote of the examining committee is required for the candidate to pass. In this event, the committee may, at its discretion, require minor thesis revisions and/or inform the candidate of areas of weakness revealed by the examination.
 - b. If the Advisory Committee decides that the candidate has failed the examination, it shall recommend:
 - i. When the examination may be repeated (at least one semester, or 15 weeks, later).
 - ii. If necessary, major thesis revisions, and additional research and/or course work.

B. Master of Engineering Candidates

1. Each candidate is required to pass a comprehensive oral Final Examination (closed to the public) administered by the Advisory Committee. Presentation of the project report is part of the examination.
2. On the basis of the candidate's performance in the examination and the quality of the project report, the Advisory Committee will determine whether the student has passed or failed.

- a. A majority vote of the examining committee is required for the candidate to pass. In this event, the committee may, at its discretion, require minor revisions in the project report and/or inform the candidate of weaknesses revealed by the examination.
- b. If the Advisory Committee decides that the candidate has failed the examination, it shall recommend:
 - i. When the examination may be repeated (at least one semester, or 15 weeks, later);
 - ii. If necessary, major revisions of the project report, and additional project and/or course work.

C. Ph.D. Candidates

1. Preliminary Examination

The preliminary examination consists of two parts. A written part in the student's area of concentration (aero-hydrodynamics, dynamics and control, structures, ocean engineering, applied physics, space engineering, or applied mathematics) and an oral part centered on research. The objective of the two-part exam is to determine if the student has the ability and preparation to undertake Ph.D. level research.

a. Written Part

- i. The purpose of the written examination is to assess the student's knowledge of general and advanced material in their area of concentration. The written exam questions are set and approved by the group of faculty in the student's area of concentration. Students in the same area of concentration receive the same exam. Faculty members in the group decide the specific scope of material to be tested by this exam, which may include material from core courses, and inform potential exam candidates of this information in a syllabus. The syllabus may take the form of a book, topic, or course list, or any other form appropriate to the area of concentration. It is also expected that groups will publish sets of sample questions, or questions from earlier years. For the exam itself, faculty in the group develop a set of questions that, as far as possible, test the students ability to integrate material from different parts of the area of concentration in the solution of problems.
- ii. The exam will be open book and open notes, and is designed to last 3-4 hours. However to minimize the pressure of time, students are allowed up to 8 hours (during the course of a single day) to complete their exam. Exams in all areas of concentration take place simultaneously and are coordinated by the Chairperson of the Graduate Committee. The Chair distributes the exams to the students and collects them at the end of the test period. The Chair then separates the exams by question and all of the solutions to a particular question are given to the author of that question. The author of the question grades and returns the solutions to the Chair, and the Chair reassembles the exam papers of each student. The complete exam for each student is then reviewed individually by each faculty member in the student's research Advisory Committee. Each faculty member makes an independent judgment as to whether the student has passed, marginally passed, or failed and communicates that vote to the Chair of the Graduate Committee. The Chair tallies the votes and reports the results to the group. A majority of positive votes (i.e. "pass" or "marginal pass") is required for the student to pass. Students who pass may proceed to the oral examination, described next.

b. Oral Part

- i. The purpose of the oral examination is to assess the student's ability to do PhD level research. This assessment will require the student to demonstrate an understanding of his

or her research, including assumptions needed, related approaches, and preliminary results if available. The student should be able to describe, using analysis where appropriate, the strengths and weaknesses of his or her and other approaches. The oral examination is administered by the student's research Advisory Committee.

- ii. Assuming that the student passes the preliminary written exam, the oral exam must take place no more than 4 weeks from the date of the written exam. The oral exam begins with a presentation by the student of his or her research, and then proceeds with questions from the faculty members designed to clarify in their own minds whether the student has demonstrated sufficient ability to perform PhD level research. The oral examination is scheduled as the official Preliminary Examination through the Graduate School. The Graduate School requires 2 weeks notice, in order to verify the student's Plan of Study and process paperwork. Therefore, the Preliminary Oral Exam must be officially scheduled *prior* to taking the Preliminary Written Exam. The date, time, and location for the Preliminary Oral Exam should be determined by the Advisory Committee Chair, in consultation with the Advisory Committee. It is the student's responsibility to ensure that the exam is officially scheduled with the Graduate School.
 - iii. The decision by the Advisory Committee to pass or fail the student is based on signatures on the online "exam card" provided by the Graduate School. A candidate is allowed at most one negative vote. The committee may issue a conditional pass. Students who pass the preliminary written exam but fail the preliminary oral exam are not required to retake the preliminary written exam.
- c. Timing and Eligibility Requirements
- i. In order to take the written preliminary examination, the student must establish his or her eligibility by completing the appropriate eligibility form and returning it to the AOE Graduate Committee Chair four weeks prior to the scheduled date of the written examination. The student's Advisory Committee is responsible for checking the student's eligibility. To be eligible, the student's GPA, based on the courses in the Plan of Study must be 3.1 or greater and the student must have a properly formulated committee and have filed an approved Plan of Study.
 - ii. The written preliminary examination will be offered once per year, on the 3rd Monday in September. The oral exam will follow according to the above 4-week requirement and must be completed at least 6 months prior to the final exam.
 - iii. Students pursuing the Ph.D. must take the written preliminary exam by the 3rd opportunity. For example, a student entering a Ph.D. program in the fall must take the written preliminary exam no later than the fall of their third year in the program.
- d. Students may have no more than two opportunities to take the preliminary exam. Therefore, a student who failed the written part could retake it, but would then have to pass both written and oral components at that time.
- e. Exemptions: In unusual circumstances (such as illness, an unusual Plan of Study, problems with transition, etc.), an individual exemption may be granted to the above rules and policies by a majority vote of the Graduate Committee, provided the exemption does not conflict with Graduate School policy.

2. Final Examination

- a. Each candidate is required to take an oral Final Examination which is primarily the defense of the dissertation but not limited to it. The exam will be conducted by the Advisory Committee and will

include a presentation of the dissertation by the candidate and a questioning period open to the public.

- b. On the basis of the Final Examination, quality of dissertation and the candidate's overall academic record, the examining committee will make a recommendation as to the acceptance of the dissertation and the awarding of the Ph.D. degree.
- c. The committee shall either pass or fail the candidate. For the candidate to pass, there must be no more than one negative vote. In the event of a passing decision, the committee shall indicate any minor revisions which may be required in the dissertation. In the event of a failing disposition, the committee shall recommend:
 - i. If and when another examination shall be permitted (normally the following semester).
 - ii. Additional research and major revisions of the dissertation.

VII. FINAL PROCEDURES

1. An application for degree must be submitted on HokieSpa on or before October 1st for a Fall degree completion date or March 1st for a Spring degree completion date.
2. At least three weeks prior to the final exam, the student must submit the request to be admitted to the final exam to the Graduate School. Students must be registered during the semester in which they plan to complete the final exam. If the defense is to take place near the beginning of a new term, a candidate may apply for "Start of Semester Defense Exception" using the following form:
http://graduateschool.vt.edu/forms/academics/Start_Semester_Defense_Exception.pdf.
The form must be submitted to the Graduate School at least three weeks prior to the date of the final exam.
3. Final fees are charged to the student's account by the University Bursar once the form(s) have been submitted. Fees must be paid in full in order for a student's degree to be awarded.
4. The final examination card is available in the final exam system to the student's Advisor prior to the day of the examination. The card must be electronically signed by the Advisory Committee and submitted to the Graduate School immediately following the examination.
5. Required examinations are administered during regular academic semesters or sessions, i.e., between the first day of classes for a given semester or session and ending with the last official day for examinations. Permission to schedule an examination in the time between sessions may be granted if an explanation of special circumstances requiring that scheduling is made to the Dean's office of the Graduate School by the student's Advisor. Scheduling of examinations between semesters/terms does not alter ETD submission or approval deadlines. If a student is unable to complete all requirements by the ETD submission or approval deadlines, the student will be required to submit the Start of Semester Defense Exception Request Form to enroll in Defending Student Status for the following term. See:
http://graduateschool.vt.edu/graduate_catalog/policies.htm?policy=002d14432c654287012c6542e3630014
6. A final version of the thesis or dissertation must be submitted to the Graduate School in PDF form (<http://etd.vt.edu>) within two weeks after the final examination. The ETD Approval Form must be included and signed by the student and the Advisory Committee members.
7. Each student is encouraged to publish the thesis or dissertation. However, such plans should be discussed with the student's Advisor with particular attention given to authorship, procedure, and journal of interest.

VIII. EVALUATION OF THE PROGRESS OF GRADUATE STUDENTS

1. Graduate student grades are reviewed each academic term by the AOE Graduate Committee, the Department Head, and the Graduate School. Students whose graduate GPA falls below 3.0 are warned that they are performing below the acceptable standard and must improve. Normally, students are allowed one semester in which to raise their GPA to 3.0 before any formal action is taken. If adequate improvement is not made during this grace period, students may be dropped from the degree program, depending upon the severity of academic deficiency.
2. The work performance of each student supported on a Graduate Assistantship is reviewed each academic term by the student's Advisor and, if necessary, by the Department Head. If the performance has been substandard, then the student may be warned that improvement is required, or, if circumstances warrant, the student may lose the Assistantship.

IX. ATTENDANCE AT DEPARTMENTAL LECTURES

1. The AOE Department has a regularly scheduled Graduate Seminar (AOE 5944). Resident AOE graduate students who are enrolled for at least 9 credit hours are required, in addition, to register for this one credit seminar each semester and to attend the weekly lectures. This seminar includes presentations by students, faculty, and visiting lecturers. The seminar serves the graduate student by broadening the student's background, improving the perspective on engineering research, and informing the student of the types of work in progress in government, industry, here and at other universities. The seminar is a pass-fail course whose only requirement is to attend the lectures. In order to pass, a student may miss no more than three lectures in a semester. In exceptional circumstances, a faculty Advisor may excuse a student's absence by notifying the faculty member organizing the seminar course.
2. Every AOE graduate student completing an M.S. degree with thesis or a Ph.D. dissertation makes a public presentation of the research. Although some of these presentations may be given at the Graduate Seminar, many are not. AOE graduate students are strongly encouraged to attend as many of these degree research presentations as possible.