AERONAUTICS & ASTRONAUTICS

UNIVERSITY *of* WASHINGTON

College of Engineering

2011

Graduate Handbook

FOREWORD

The Department of Aeronautics and Astronautics offers the only program of its kind in the Northwest. While the department prepares undergraduates through classroom instruction, laboratory experience, and special projects, graduate courses and research extend further into the sciences of aeronautics and astronautics, engineering physics, and applied mathematics. Our students and faculty come from various engineering and science backgrounds.

The Master of Science and Master of Aerospace Engineering programs are designed to provide graduates a high level of technical competence for careers as professional engineers, and the PhD program is directed to the training of engineers for research leadership roles.

Almost all of the regular faculty maintain funded research programs. The interests of the department cover the traditional areas of aeronautics and astronautics, and they also extend into those interdisciplinary areas where many of today's challenges are to be found. This brings currency and excitement to the program and ensures contact with the future. While the impact of aircraft and space vehicles on our society is pervasive, the engineering sciences associated with the aerospace industry have even wider applications.

The Department of Aeronautics and Astronautics looks forward to maintaining its long tradition of excellence in the strong academic atmosphere of the University of Washington and this wonderful region of the country.

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CONTENTS

ACTIVE RESEARCH AREAS

Aerodynamics and Fluid Mechanics

Aerodynamics and fluid mechanics will continue to pace developments in the aerospace and aerospace-related industries. Department research in these areas covers a wide spectrum from analytical to experimental development of models for vorticity - dominated flows. These areas include turbulence modeling studies using experimental methods, novel diagnostic development, vortex breakdown, mixing in combusting and non-combusting environments, accelerating turbulence, and boundary-layer control through use of stationary vortices. Other projects use existing fluids technology in new applications which are referred to under other headings.

Air Breathing Propulsion

Development of a competitive aircraft gas turbine engine remains one of the most challenging tasks in aeronautics. Among the key issues pertaining to aircraft gas turbine components, advancements in the "hot" sections, such as combustors and turbines, are deemed to be one of the enabling technologies. Active programs carried out in the department include incorporating innovative ideas are to lessen pollutant emission from combustors. The successful development of hypersonic vehicles represents another important challenge in air breathing propulsion. Research in this area explores novel strategies for promoting effective fuel injection and fuel/air mixing in supersonic flows.

Automatic Controls

Almost every engineering or physical system needs control in some form or another to improve performance as well as robustness with respect to disturbances and model uncertainties. Systems requiring control can range from the more conventional electromechanical systems (e.g., aircraft, spacecraft, robots, actively controlled structures, manufacturing processes, power generation) to biological systems (e.g., natural resource management, medical support systems involving patients). Our research interests include the fundamental techniques for design and analysis of control systems for such diverse applications. Because controls spans such a wide range of applications, the controls program at the UW is cross-departmental, with students and faculty from Aeronautics and Astronautics, Electrical Engineering, and Mechanical Engineering cooperating closely in research and education. Research activity spans modern model-based techniques for multivariable systems (direct optimization based methods, robust design methods) as well as investigation of unconventional approaches based on artificial neural networks, fuzzy logic and genetic algorithms.

Composite Materials

Structural engineering in the aerospace industry has changed dramatically in the past decade, with the advent of carbon fiber reinforced plastics (CFRP). CFRP offer superior stiffness and strength-to-weight properties, as well fatigue and corrosion resistance. The new composite technology has an impact not only on the aerospace industry, but also on many other industries in the global economy. Our research programs in composite materials aims at developing experimental and numerical tools to characterize the damage resistance and tolerance of composite-intensive airframes, including high-velocity or high-energy impact events such as bird strike, hail strike, lightning strike and crashworthiness. This includes the development of physics-based predictive tools for composite material failure, targeting both traditional autoclave prepreg materials as well as new composite material forms manufactured by low-cost techniques. The A&A department and its associated composites laboratory participate in the Federal Aviation Administration-sponsored Joint Advanced Materials and Structures Center of

Excellence. The Center is a consortium of academic institutions, aerospace companies, and government agencies seeking solutions to problems associated with near- and long-term applications of composites and advanced materials for commercial aircraft. The emphasis of the research is on safety and certification initiatives for composites. The presence of organizations such as The Boeing Co., Toray Co. of America and the FAA certification office in the Puget Sound area provides the ideal background for these activities.

Computational Fluid Mechanics

Computational fluid mechanics (CFM) focuses on computational methods that examine the fundamental fluid mechanics of single-phase, multi-phase, and multi-species turbulent flows for engineering applications, e.g., internal and external aerodynamics, and propulsion, and for understanding of natural phenomena. The CFM group develops numerical methods and algorithms for parallel supercomputers to perform state-of-the-art Direct Numerical Simulations (DNS) and Large Eddy Simulations (LES) of turbulent flows using high-performance computing (HPC). Multidisciplinary research in collaboration within the School of Engineering and with other departments, e.g. Applied Math, Atmospheric Science, Oceanography, and Biology, is encouraged in the CFM group.

Energy Conversion

The energy and power available play a dominant role in the characteristics of all vehicles. Ground transportation, atmospheric and space flight vehicles depend on primary resources such as fuels for the accomplishment of their missions. The conversion processes of fuel energy to useful forms, such as jet power, must be efficient, low in environmental impact, and economically viable. The fundamentals of energy interactions with fluids are critical to the successful design of power and propulsion, and analysis of engines, turbo machinery, magnetohydrodynamics, power generation in space, nozzle flows, photovoltaics, and lasers to mention a few. Active programs in energy research include the study of technologies for the efficient, low-emission combustion of hydrocarbon fuels.

Gas Physics

Application of high-energy flow to propulsion, gasdynamic and chemical production requires a detailed knowledge of kinetics of vibrational and electronic energy transfer, radiation cross-sections, and chemical rate processes. The Aeronautics and Astronautics faculty are engaged in fundamental studies of these processes, along with the development of computational tools for modeling them in high-enthalpy, non-equilibrium flow.

Heat Transfer

Heat transfer is a critical element in a wide variety of aerospace applications. Key areas under study in the department include convective and radiative heat transfer to conical bodies at high Mach number flight, and analysis and measurement of the effects of thermal boundary layers on the performance of gas dynamic chemical reactors. Other research is focused on cooling intakes of high-speed aircraft engines with liquid spray, and evaluation of coatings for insulation of high-speed projectiles and rocket surfaces under high-enthalpy flow.

Plasma Physics

The plasma physics group's primary interest is nuclear fusion, particularly new confinement concepts and innovative improvements to tokamaks. The current research involves flowing plasmas, and is thus related to fluid mechanics and magnetohydrodynamics (MHD). Interests also extend to plasma propulsion. In the area of new confinement concepts, an ongoing area of investigation is compact toroids, which have the ability to make considerable simplifications in fusion reactor design. Fundamental plasma questions involve helicity conservation and its effect on confinement, and sheared plasma flows and kinetic particles and their effects on stability. Current research involves the use of helicity injection to sustain the current in spherical tokamaks and spheromaks, high density Z-pinches stabilized by sheared plasma flows, and novel electrostatic thruster concepts. There is also a significant effort on computational algorithm development for advanced plasma models, theoretical analysis, and MHD code development.

Numerical, Experimental and Theoretical Solid Mechanics

The study of solid mechanics deals with the behavior of solid materials: the deformations, motions, and internal states of solids and structures that arise in their use in some engineering applications. Aerospace structures are unique in their challenging light weight/high performance requirements. Examples are apparent all around: the bending of a composite airplane wing under wing loadings, the internal stresses in the booster rocket during a space vehicle launch, the action of a piece of space debris impacting a space vehicle. To design such applications requires an underlying understanding of the theoretical mechanics of solids, effective means for applying that theory to predict the response of a structure to all conditions expected in its intended application, and effective design optimization capabilities that can optimize an objective or a set of objectives subject to constraints that protect against all possible failure modes.

LABORATORY FACILITIES

Automobili Lamborghini Advanced Composites Structures Laboratory
http://www.aa.washington.edu/research/structures/

Autonomous Flight Systems Laboratory
http://www.aa.washington.edu/research/afsl/

Computational Fluid Mechanics
http://www.aa.washington.edu/research/cfm/

Computational Plasma Dynamics
http://www.aa.washington.edu/research/cfdlab/

Combustion and Gas Dynamics
http://www.aa.washington.edu/research/combustion/index.html

Distributed Space Systems Laboratory
http://www.aa.washington.edu/research/dssl/index.html

Flow Z-Pinch Experiment (ZaP)
http://www.aa.washington.edu/research/ZaP/index.html

Fluid Dynamics & Aerodynamics
http://www.aa.washington.edu/research/fluidDynamic/index.html

Kirsten Wind Tunnel/UWAL (8' x 12')
http://www.aa.washington.edu/uwal/

Mars Environmental Research Facility
http://www.aa.washington.edu/research/ISRU/

Microgravity Science
http://www.aa.washington.edu/research/microgravity/index.html

Nonlinear Dynamics and Control Laboratory
http://www.aa.washington.edu/research/ndcl/index.html

Plasma Dynamics Laboratory
http://www.aa.washington.edu/research/plasmaDynamics/

Plasma Science and Innovation (PSI) Center
http://www.aa.washington.edu/research/PSI/

Steady Inductive Helicity Injected Torus (HIT-SI)
http://www.aa.washington.edu/research/HITsi/

ADMISSION CRITERIA

All prospective graduate students must be accepted into the Graduate School of the University of Washington as well as to the Department of Aeronautics & Astronautics.

Admission to the University of Washington Graduate School is necessarily a selective process. Prospective students must hold a baccalaureate degree from an accredited college or university in this country or its equivalent in a foreign country. Their record should be a strong one with an average grade of B or better. The primary criterion and the priority for admission of new applicants into a graduate program is their ability, as decided by the University, to complete the graduate program expeditiously with the highest level of achievement in their academic career.

The University of Washington reaffirms its policy of equal opportunity regardless of race, color, creed, religion, national origin, sex, sexual orientation, age, marital status, disability, or status as a disabled veteran or Vietnam era veteran. This policy applies to all programs and facilities, including, but not limited to, admissions, educational programs, employment, and patient and hospital services. Any discriminatory action can be a cause for disciplinary action. Discrimination is prohibited by Presidential Executive Order 11246 as amended, Washington State Gubernatorial Executive Orders 89-01 and 93-07, Titles VI and VII of the Civil Rights Act of 1964, Washington State Law Against Discrimination RCW 49.60, Title IX of the Education Amendments of 1972, State of Washington Gender Equity in Higher Education Act of 1989, Sections 503 and 504 of the Rehabilitation Act of 1973, Americans with Disabilities Act of 1990, Age Discrimination in Employment Act of 1967 as amended, Age Discrimination Act of 1975, Vietnam Era Veterans' Readjustment Assistance Act of 1972 as amended, other federal and state statutes, regulations, and University policy. Equal Opportunity and Affirmative Action compliance efforts at the University of Washington are coordinated by the Office of Equal Opportunity and Affirmative Action, University of Washington, 231 Gerberding Hall, Box 351240, Seattle, Washington, 98195-1240, telephone 206.543.1830 or email eoaa@u.washington.edu. The University of Washington is committed to providing access and reasonable accommodation in its services, programs, activities, education and employment for individuals with disabilities. To request disability accommodation in the application process, contact the Disability Services Office at least ten days in advance at: 206.543.6450/V, 206.543.6452/TTY, 206.685.7264 (FAX), or dso@u.washington.edu.

Admission to the department is competitive, and <u>all</u> components of an application (as discussed below) will be considered in evaluating eligibility for admission.

1. Grade Point Average (GPA)

Applicants to the graduate programs should be well prepared and have a strong undergraduate GPA for the last 90 quarter hours or 60 semester hours of graded undergraduate course work to be considered for admission.

2. Quality and Difficulty of Courses Taken and Universities and Colleges Attended

Each transcript is individually reviewed. The department recognizes that some academic institutions are more competitive and high grades are more difficult to obtain.

3. GRE General Test

The department requires applicants to take the general portion of the Graduate Record Examination. Information is available at: www.gre.org or through the Educational Testing Service: http://www.ets.org.

Scores must be no more than five years old. If you wish to be considered for a graduate assistantship or fellowship, the scores should be received by January 15th.

4. Letters of Recommendation (2)

The confidential letters can be submitted electronically by recommenders indicated on the on-line application, or may be placed in sealed envelopes and included with application materials, or sent directly to the department by the recommenders. Writers should be in a position to rank the applicant's performance as a student and/or researcher. We do not have special forms for recommendations, but ask that the referee send the recommendation in letter format.

5. Statement of Objectives

A statement of objectives should be written providing the department with information about applicants not found in their transcripts and other official documents. For example, statements can include personal histories, professional and academic goals, and specific research interests if applicable.

6. English Requirements for Foreign Nationals

The University of Washington requires TOEFL scores for foreign nationals whose native language is not English. The minimum acceptable score is 580, 237 on the computerized exam, or 92 on the TOEFLiBT. However, applicants with scores slightly below will be considered for admission if other aspects of their applications are strong. Further information on English Language Ability for Admission to the Graduate School may be found at:
http://www.grad.washington.edu/policies/memoranda/memo08.shtml

Students admitted with TOEFL scores below the minimum will be required to take designated Academic English Program courses through the UW English Language Programs at an additional cost. Students who intend to apply for teaching assistantships must meet additional requirements discussed in the UW Graduate School Memorandum 15: http://www.grad.washington.edu/policies/memoranda/memo15.shtml

7. Undergraduate Degree

Prospective students should hold an undergraduate degree in aerospace or mechanical engineering. Applicants with strong grades in related disciplines (physics, other engineering disciplines) will be considered.

INTERNATIONAL STUDENTS

International graduate students constitute an important segment of the Graduate School. The University of Washington encourages academically qualified applicants from other countries and also those noncitizen applicants who are attending, or have degrees from, other universities in the United States. International applicants must be prepared to provide evidence that they will have available approximately $46,000 for each nine-month academic year of study. FAQs for International Students may be seen at: http://www.grad.washington.edu/admissions/Application/f_a_q_international.htm

APPLICATION PROCEDURES AND DEADLINES

Master's and PhD Applications:
The application process is two-step, with some documentation going to the Graduate Admissions Office and some going to the A&A department. Deadlines and application instructions follow. Applications are accepted for the autumn quarter only for matriculated students.

The following items must be submitted to the *Graduate School*:

- Online Graduate School Application and payment of application fee: https://www.grad.washington.edu/applForAdmiss/
- GRE scores will be submitted electronically (the UW Institution Code, for reporting purposes, is: 4854).
- **International Students Only**:
  Submit scores for the Test of English as a Foreign Language (TOEFL), or an equivalent exam approved by the Graduate School. For more information, contact the University's Office of Educational Assessment http://www.washington.edu/oea, or the Educational Testing Service: http://www.ets.org

The following items must be submitted to the *Department of Aeronautics & Astronautics*

- One copy of official transcripts from all colleges and universities attended (Attn: Graduate Program)
- Two letters of recommendation (submitted electronically via request through the on-line application, or may be placed in sealed envelopes and included with application materials, or sent directly to the department by the recommenders).
- Statement of Objectives (submitted electronically via the on-line application).
- Financial Assistantship application, if appropriate (submitted electronically via the on-line application): http://www.aa.washington.edu/admissions/grad.html

Graduate Non-matriculated (GNM) Applications:
The following items must be submitted to the ***Graduate School*:**

- On–line GNM application: https://www.grad.washington.edu/applForAdmiss/

International Students Only:

- Foreign nationals are not eligible for student visas under the GNM program.

The following items must be submitted to the ***Department of Aeronautics & Astronautics,***
attn: Manager of Graduate Programs:

- One copy of official transcripts from all colleges and universities attended.

Application Deadlines:

The Department of Aeronautics & Astronautics accepts applications for autumn quarter admission only. Application materials for regular status (full-time and part-time, on-campus) must be submitted by January 15th of the application year for autumn quarter.

The online (EDGE) deadline is later than the department deadline. It is:

Autumn Quarter - July 1st of application year

The deadlines for Graduate Non-matriculated (GNM) applications (either on-campus or online) are as follows:

Autumn Quarter - August 1st of application year

Winter Quarter - November 1st of previous year

Spring Quarter - February 1st of application year

REGISTRATION STATUS

Regular Status, Residential Program
This option is intended for full-time students pursuing a degree in residence at the University of Washington. Most Master's and PhD students fall under this category.

Regular Status, Part-Time
This category is for students who are working full-time in local industry while pursuing a degree part-time on the campus of the University of Washington.

Online Status-- EDGE
In this program, part-time students may complete their course work online:
http://www.outreach.washington.edu/uweo/programs/edge/
Status may be either Regular or GNM (see below).

Graduate Non-Matriculated (GNM)
The GNM program permits students to take up to 12 credits of graduate courses or advanced undergraduate courses. The majority of GNM students attend part-time, although full-time enrollment is not prohibited. The advantage of this program is that it allows students to take graduate courses regardless of degree objectives. Students whose academic record falls short of the admission criteria may also be advised to enroll as GNM before applying for regular status.

Although applicants must hold an undergraduate degree in engineering or related discipline, present official transcripts and have earned a grade point average (GPA) deemed satisfactory by the department, Graduate Record Examination (GRE) scores and recommendation letters are not required. Qualification for admission is decided quickly. Furthermore, up to 12 credits of appropriate GNM courses passed successfully may be applied to a degree if students are admitted into a degree program at a later date.

Admission into regular status from GNM status requires that students apply for regular admission to the department, which is competitive with all applicants to the program. They should have taken at least three graduate-level courses applicable to a degree in Aeronautics and Astronautics (500 level and above) and attained competitive grades in each course. Submission of GRE test scores (general exam) is also required.

If students are reapplying to the Graduate School, previous application materials are maintained in the department office. They need only resubmit the "Application to Graduate School" along with the application fee. Once the status of a GNM student is changed to regular graduate status, all courses suitable for the program taken as GNM students (no more than 12 credits) will be credited toward the their degree.

RESIDENCE CLASSIFICATION

Status as a resident or nonresident of Washington determines the amount of tuition and fees required. Students are encouraged to apply for resident status as soon as they are eligible.
http://www.washington.edu/students/reg/residency/domicile.html
Alternately, non-resident graduate students may be eligible for an operating fee-waiver of the differential between resident and nonresident tuition. This applies to those graduate students who have lived in the state for at least one year (except students whose visa status precludes them from establishing permanent residency) and who have applied for resident status but *failed to overcome the presumption they are residing in Washington primarily for educational purposes*. Information may be found at:
http://www.washington.edu/students/reg/residency/graduateProfessional.html

ACADEMIC YEAR

The University operates on the quarter system. Instruction is offered for 10 weeks each in Autumn, Winter, and Spring Quarters, and nine weeks during the Summer Quarter. Terms begin in September, January, March and June.

FINANCIAL ASSISTANTSHIP

Limited departmental financial aid is available for full-time, regular status students. Three types of financial aid are offered: Teaching Assistantships (TA), Research Assistantships (RA), and Fellowships. The Assistantship Application form is available on our web page:
http://www.aa.washington.edu/admissions/grad.html

TA and RA positions involve 20 hours of work per week; assistantships are typically considered 50%-time appointments. The monthly salary varies depending on the degree level and status. For the 2011-12 academic year, the monthly 50%-time starting salary is $1525 for TA's and $1,845 for RA's. Appointee insurance is covered by the University; appointees receive a waiver of tuition, but are responsible for nominal quarterly fees of approximately $250. RA's and TA's at the UW are covered under the UW/UAW Union Contract. More information about the contract is available at:
http://www.washington.edu/admin/hr/laborrel/contracts/uaw/addons/index.html

Appointments vary in length, depending on the source of funding and the nature of the work.

Teaching Assistantships may be held by foreign nationals whose native language is not English only if they meet the requirements detailed in UW Graduate School Memorandum 15, "Conditions of Appointment for TAs who are not Native Speakers of English"
http://www.grad.washington.edu/policies/memoranda/memo15.shtml

Financial assistance is offered on a competitive basis. Those applicants with the very best records may be offered, in addition to assistantships, fellowships of up to $5,000 for their first year. Some special fellowships and RA's are also available in the department through the Graduate School and other sources. Offers of assistantships to applicants are usually made for the initial three-quarter period of association with the department. Financial aid offers for Autumn Quarter applicants are made in March. Typically, 90% of the financial aid available for new students is offered and accepted by late April.

Some graduate students enter the program as Teaching Assistants, learn about the program and its faculty, and then in the second or third quarter of study are hired into RA positions. **RA positions are generally offered to PhD students and MS students whose ultimate degree goal is a PhD. Students pursuing a terminal master's degree (non-thesis MSAA or MAE) may be considered for TA positions.**

Typical TA duties involve grading homework and exams, and instruction of laboratory and homework recitation sections of undergraduate courses. Teaching Assistants are also requested to tutor and occasionally give lectures. TA appointees are supervised by the faculty member who lectures and manages the course.

Research Assistants serve directly on research projects managed by faculty members. They perform a variety of tasks, from running experiments and analyzing data, to developing and performing computational analyses and writing reports. Applicants who wish to begin an RA as early as possible should contact faculty members in their interest areas before they enter the program. It is the student-faculty contact and negotiation that leads to most RA appointments:
http://www.aa.washington.edu/faculty/index.html

Students are also encouraged to seek outside sources of support, including fellowships from the National Science Foundation, the Department of Defense, other federal agencies and laboratories, private foundations, and foreign governments. The Graduate School has a list of fellowship resources: http://www.lib.washington.edu/gfis/subjects.html

Reappointments

1. TA Positions

TA selections are made at the start of each quarter by the department according to the specific requirements of the faculty and the course offerings that quarter. There is no general expectation that a TA appointment will continue more than one quarter. The general policy is that long-time and PhD level students should not expect to be continually supported with TA positions, but instead should become associated with particular faculty and be supported as RAs under their grants.

2. RA Positions

All RA selections are made by the individual faculty members whose grants and contracts have funds for those positions, and are generally offered to students who intend to pursue a PhD.

Financial Support Limits

Master's students can be supported with an assistantship for a maximum of 2.5 years.
Postmaster's students have a maximum limit of 6 years of financial support in the form of RA's or TA's.

GRADUATE DEGREE PROGRAMS

Graduate degrees offered by the Department of Aeronautics & Astronautics include:

- Master of Aerospace Engineering (MAE)
- Master of Aerospace Engineering- Composite Materials & Structures (MAE-CMS)
- Master of Science in Aeronautics and Astronautics (MSAA)
- Doctor of Philosophy (PhD)

Introduction

These guidelines are intended to help familiarize graduate students with the policies governing the graduate programs leading to the degrees of Master of Science in Aeronautics and Astronautics (MSAA), Master of Aerospace Engineering (MAE), and Doctor of Philosophy (PhD). This material supplements the official University Catalog, which contains further Graduate School regulations and degree requirements. Students are responsible for knowing the Graduate School degree requirements, which may be found at: www.grad.washington.edu

Initial Advising Appointment

After paying the deposit to hold their place at the University (full-time, on-campus students only), students will receive a registration card from Graduate Admissions. They may register any time after their appointed date. Graduate classes do not generally fill up so they may wait until they move to Seattle. As long as they register before the quarter begins, they will not get charged a late registration fee and should be able to get the classes of their choice. Students should make an appointment with the Graduate Advisor at least two weeks prior to the beginning of the quarter.

Continuous Enrollment Requirements

All matriculated students must be continuously enrolled, or apply to be on-leave for any quarter they intend to take off. A Petition for On-Leave Status (http://www.grad.washington.edu/forms/on-leave-request.pdf) must be submitted to the department for approval each quarter students want to be on leave. There is a $25 fee per quarterly on-leave request. Leave requests will only be approved for students who are making satisfactory progress.

Master's Students

All Master's students must have a program of study plan approved by the Graduate Committee of the Department of Aeronautics & Astronautics. Students should submit their program plans to the Graduate Advising Office before completing twelve credits of graduate course work. The plans can be prepared with the assistance of their research advisors or with the Graduate Program Advisor. Program plans will be submitted to the Graduate Committee for approval. *Courses taken outside those in the suggested program plans (below) must be approved prior to registration or may not be counted toward the degree.* All courses that count toward the degree must be graded. Students must receive grades of at least 2.7 in each course for it to count toward their degree, and must maintain a cumulative GPA of 3.0

The minimum MSAA program may consist of either 10 courses plus 9 thesis credits, or 13 courses. The minimum MAE program may consist of 12 courses plus 8 credits for an independent or team project (or an approved certificate program).

MSAA students' programs of study are tailored to their needs and interests. However, each program must include depth in a field of specialization, breadth to include at least one course in each of two different subject areas outside the field of specialization, and analytical strength to include three

mathematical courses. Senior sequences in engineering, science, or other appropriate professional fields may be used to make up part of the graduate program (though not in the depth area).

MAE students' programs of study are tailored to their needs and interests. However, each program must include core courses in a field of specialization, technical electives, non-technical electives, a free elective, and mathematics (numerical methods, and probability and statistics). In addition, MAE students complete an independent or team project (or complete an approved Certificate Program).

At the beginning of the quarter in which they expect to receive their Master's degree, students must apply online for graduation: https://www.grad.washington.edu/student/mastapp.aspx

The thesis, if that MSAA degree option is chosen, is approved by the students' advisors and a second reviewer. A PDF copy on disc must be submitted to the A&A department, and two signed, unbound copies of the thesis and receipt for binding fee must be submitted to the Graduate School by the last day of the quarter. The MAE independent or team project report is approved by students' advisors, and a copy submitted to the department on disc. Both thesis-track MSAA and MAE students should make a presentation of their thesis/project to their advisor(s).

It usually takes 1.5 - 2.0 years of full-time study to complete the requirements for a Master's degree. The Graduate School imposes a time limit of 6 years for any Master's degree.

Master's students must also meet the UW Graduate School requirements, a summary of which is available at: http://www.grad.washington.edu/policies/masters/requirements.shtml

PROGRAM PLANS AND DESCRIPTIONS

Master of Aerospace Engineering (MAE)

The Master of Aerospace Engineering is intended to be a practice-oriented master's degree program for either recent graduates or engineering professionals who wish to expand their knowledge in specific technical areas or broaden their skills in new areas, while also learning about other aspects of aerospace engineering, such as business, management, manufacturing, or communication. The MAE program is designed to be multidisciplinary and is aimed at developing practical engineering skills needed in industry. The program requires 12 courses and 8 credits of independent or team project work. No thesis is required but written and oral reports must be submitted at the conclusion of the project. The curriculum is anchored by four courses in one of several departmental core subject areas, and by 2 mathematics courses (numerical methods and statistics). Electives comprise a total of six courses, of which 3 must be technical electives from any department in the College of Engineering and 2 must be in the areas of business and management, manufacturing, systems analysis, or technical communication. The remaining course may be freely selected in any technical or non-technical area of interest to the student. A student may take additional mathematics courses as electives, if relevant to a particular technical area of interest. The project may be a laboratory experiment, team or independent design study, work-related project, or other project selected in consultation with a faculty advisor or the Graduate Program Advisor. There are three Certificate Programs that may substitute for the independent or team project *and* the Business/ Manufacturing/Systems classes (see below).

Master of Aerospace Engineering Program Structure

Program Structure: Listed by Academic Quarter: A, W, and Sp denote Autumn, Winter, and Spring quarters. Schedule shown is an example; it may vary depending on core subject schedules and individual variances. Credit hours are shown in parentheses. For certain courses the number of credit hours may be greater.

A	W	Sp	A
CORE (3)	CORE (3)	CORE (3)	CORE (3)
Mathematics (5) (Numerical Methods) Bus./Mfg./Syst (3-)	Technical Elective (3) Technical Elective (3) Independent or Team Project (3)	Mathematics (4) (Probability & Stat.) Bus./Mfg./Syst. (3-) Independent/Team Project (2)	Technical Elective (3) Free Elective (3) Independent or Team Project (3)

Core Subject Areas:

- Control system engineering
- Fluid mechanics
- Propulsion and power
- Structural mechanics

Note: The Certificate in Business Administration, or the Entrepreneurship Graduate Certificate, or the AA 595/596 Global Integrated Systems Engineering Certificate can substitute for the two Bus/Mfg/Systems classes and the independent or team project.

Each of these core subject areas offers options. For example, in the area of control system engineering there are three possible program options: flight controls, robotics, and structural controls, while in fluid mechanics students can specialize in aerodynamics, physical gas dynamics, or computational fluid dynamics. The propulsion and power option offers two possible paths: air breathing propulsion and space propulsion and power. The structural mechanics option may also be tailored to specific interests. Some of these core options are available in alternate years only.

Mathematics: Two courses must be taken, one in numerical methods, the other in probability and statistics.

Electives: A wide variety of electives are available both within and outside the Department of Aeronautics & Astronautics. Students thus have considerable freedom to tailor a program of study to their particular professional interests. Business and management courses are offered by the School of Business, manufacturing and systems courses are available through Industrial Engineering, and technical communication courses through the Human Centered Design and Engineering Department. The UW General Catalog should be consulted for details.

Department of Aeronautics & Astronautics

MAE PROGRAM PLAN FORM

Name

Status: __Full Time __Part-Time __Online

Program Started: Quarter: Year:

Expected Degree Completion: Quarter: Year:

This program plan must be submitted to the Graduate Committee for approval to ensure that courses taken will count toward graduation requirements. Prior to submitting program plans, all students should discuss their proposed plan with a professor in the core area and/or with the Graduate Program Advisor. All courses to be used toward the degree must be graded. A grade of 2.7 must be received in a course for it to count toward the graduate degree.

Core Courses, Choose 4 from the approved list on the next page::

Course	*Credits*	*Quarter*	*Year*	***Grade*** (to be filled in by department advising staff)

Technical Electives, Choose 3 courses from the approved list on the next page:

Course	*Credits*	*Quarter*	*Year*	***Grade*** (to be filled in by department advising staff)

Business/Manufacturing/Systems Electives, Choose 2 courses from the approved list on the next page:

Course	*Credits*	*Quarter*	*Year*	***Grade*** (to be filled in by department advising staff)

Analytical/Mathematics Electives, Choose 2 Courses from the approved list on the next page:

Course	*Credits*	*Quarter*	*Year*	***Grade*** (to be filled in by department advising staff)

Free Elective, Choose any 1 technical or non-technical graduate-level course of interest:

Course	*Credits*	*Quarter*	*Year*	***Grade*** (to be filled in by department advising staff)

Independent or Team Project, 8 credits total, to be arranged with Faculty Advisor:

Course	*Credits*	*Quarter*	*Year*	***Grade*** (to be filled in by department advising staff)
AA 600				
AA 600				
AA 600				
AA 600				

SAMPLE MAE PROGRAM PLANS

Area of Interest:	Core Courses (Choose 4)	Mathematics Courses (Choose 1 numerical methods, 1 statistics)	Technical Electives (Choose 3)	Business, Manufacturing or Systems Electives (Choose 2)	Free Elective (Choose1)	Project (8 credits)
CONTROLS	AA 516, 528, 547, 548, 597 AA 571/ME 588	STAT 421 or 481 AMATH 581 or 584 Or other graduate courses in numerical methods or statistics	Any graduate technical course in the College of Engineering Additional graduate math courses if relevant to area of interest	Any graduate course in business and management, manufacturing, systems analysis, or human centered design and engineering	Any technical or non-technical graduate-level course	To be determined with a faculty research advisor.
FLUIDS **Aerodynamics** **Physical Gasdynamics** **Computational Fluid Mechanics**	AA 503, 504, 506, 507, 508 AA 501 AA 543, 544					
PROPULSION & POWER **Airbreathing Propulsion** **Space Propulsion and Power**	AA 524, 525, ME 524, 584 AA 527, 529, 556,					
STRUCTURES	AA 530, 531, 532, 540					

Note: The Certificate in Business Administration, or AA 595/596 Global Integrated Systems Engineering Certificate Program, which are both administered through UW Professional and Continuing Education, may be substituted for the Independent or Team Project and the two Bus/Mfg/Systems classes. The Entrepreneurship Graduate Certificate, which is administered through UW Business School, may also be substituted for the Independent or Team Project and the two Bus/Mfg/Systems classes.

Suggested Non-Technical Electives for the MAE

School of Business:
ACTG 503 Introduction to Accounting for Managers (4)
B ECON 579 Special Topics in Business Economics (4)
I BUS 550 International Business Consulting (4)
MGMT 521 Strategic Management of Technology and Innovation (4)
OPMGT 550 Project Management (4) (Prerequisite: BA 502, OPMGT 502 or instructor permission)

The Certificate in Business Administration, as well as AA 595/596 Global Integrated Systems Engineering Certificate Program, which are both administered through UW Professional and Continuing Education, may be substituted for the Independent or Team Project and the two Bus/Mfg/Systems classes. The Entrepreneurship Graduate Certificate, which is administered through UW Business School, may also be substituted for the Independent or Team Project and the two Bus/Mfg/Systems classes.

Industrial Engineering
(NOTE: Classes in this department cannot be strictly classified as non-technical, but are nevertheless considered to be applicable.):
IND E 513 Linear Optimization Models in Engineering (3)
IND E 515 Fundamentals of Optimization (5)
IND E 521 Quality Control in Manufacturing (3) (offered online)
IND E 524 Robust Design and Quality Engineering (3) (offered online)
IND E 526 Reliability in Product Design and Testing (3) (offered online)
IND E 538 Large Assembly Manufacturing Systems (3)
IND E 543 Virtual Interface Technology (1/3)
IND E 544 Virtual World Development (3)

Mechanical Engineering
ME 501 Modern Manufacturing Processes (3) (offered online)
ME 505 Computer Integrated Manufacturing (3) (offered online)

Human Centered Design and Engineering:
HCDE 501 Theoretical Foundations of Human Centered Design and Engineering (4)
HCDE 502 Empirical Traditions in Human Centered Design and Engineering (4)
HCDE 505 Computer Assisted Communication (4)
HCDE 510 Information Design (4)
HCDE 517 Usability Testing (4)
HCDE 520 Design and Management of Complex Information and Communication Systems (4)

Master of Aerospace Engineering- Composite Materials & Structures (MAE-CMS)

The MAE-CMS degree is intended to be a practice-oriented master's degree program for professionals working in engineering who wish to expand their knowledge in new areas of composite materials and structures, while also learning about other aspects of aerospace engineering, such as systems analysis, manufacturing, quality control, etc. It is also designed for graduate students who wish to pursue careers in composite structures. The program is aimed at developing practical engineering skills needed in industry.

The program requires 12 courses and 8 credits of independent or team project work. No thesis is required but written and oral reports must be submitted at the conclusion of the project. The curriculum is anchored by 4 courses in the core subject area of composites, and by 2 courses in mathematics/analysis. Electives comprise a total of 6 courses, of which 3 must be technical electives from designated College of Engineering departments and 2 must be in the areas of manufacturing, systems, or business. The remaining course may be freely selected from any technical or non-technical area of interest. Students may take an additional mathematics courses as an elective, if relevant to a particular area of interest. The project may be a laboratory experiment, team or independent design study, or work-related project, selected in consultation with the Graduate Faculty Advisor. All courses, except some analytical courses and some electives, are offered online.

Graduate Non-Matriculated (GNM) students who have successfully completed the A&A department's Certificate Program on Aircraft Composite Structural Analysis and Design may transfer the 3 credits from Course 1 toward the MAE-CMS degree, to replace AA432, one of the technical electives in the degree program.

Because the MAE-CMS program is a focused program with specific course requirements, students should indicate their intent to earn this degree by applying directly to the program. Should students in the broader MAE program decide to specialize in composites, they must declare this intent by the end of their first quarter in the graduate program. All students in the program must meet with their graduate advisor to complete a plan for their program of study, which must be approved by the Graduate Committee

Sample MAE-CMS Degree Program Plan

Core Courses (4)	**Technical Electives** (3)	**Math & Analytical Courses** (2)	**Free Elective** (1)	**Systems/ Mfg/Bus Electives** (2)	**Independent or Team Project**
AA 532 (Mechanics of Composite Materials) AA 534 (Integrity of Composite Aircraft Structures) AA 535* (Analysis and Design of Composite Structures) ME/MSE 563 (Advanced Composites: Design & Manufacturing)	AA 432§§ AA 530 AA 531 AA 538 AA 540 AA 541 AA 554 AA 571 ME 541 ME 553 ME 559 ME 588 ME/MSE 562	AMATH 581 or AMATH 584 And one of ME 573 or STAT 421** or STAT 481**	Any graduate-level technical or non-technical elective or additional graduate analytical course.	AA/INDE 470 IND E 521 IND E 524 IND E 526 OPMGT 550** MGMT 521**	AA 600 (8 credits)

*New course, not yet in General Catalog

§§ AA 432 should be taken as an elective by students who have not had an introductory course in composite materials.

**Statistics and Business courses are only available to on-campus students

Master of Science in Aeronautics and Astronautics (MSAA)

The MSAA degree is intended for students with an undergraduate degree in Aerospace Engineering or a closely related field, such as Mechanical Engineering, who are interested in pursuing an advanced degree, or career in industry, government or the engineering sciences. Students' undergraduate backgrounds should include core courses in aerodynamics, flight mechanics, fluid mechanics, thermodynamics, heat transfer, mechanics of materials, dynamics, propulsion, controls or other related or equivalent subjects.

Students with an undergraduate degree in a discipline other than Aerospace or Mechanical Engineering may need additional alternative preparatory classes, which may, with departmental approval, be applied toward the MSAA degree.

There are two paths toward the MSAA degree:

- Thesis Option (10 courses plus 9 thesis credits)

  Students create their own programs of study based on departmental distribution requirements and subject to departmental approval. Submission of a thesis approved by students' advisors. Ten approved courses usually comprise the program.

- Non-Thesis Option (13 courses)

  Students create their own programs of study, consisting of 13 courses, based on departmental distribution requirements, which must be approved by the department.

Department of Aeronautics & Astronautics

MSAA PROGRAM PLAN

Name:

Status: __full-time __part-time __Online

Program Started: Quarter: Year:

Expected Degree Completion: Quarter: Year:

This program plan must be submitted to the Graduate Committee for approval to ensure that courses taken will count toward graduation requirements. Prior to submitting program plans, all students should discuss their proposed plan with a professor in the core area and/or with the Graduate Program Advisor. All courses to be used toward the degree must be graded. A grade of 2.7 must be received in a course for it to count toward the graduate degree.

Core Courses, 8 courses, or 5 plus thesis:

Course	*Credits*	*Quarter*	*Year*	***Grade*** (to be filled in by department advising staff)

Breadth Courses, Choose 2 (1 in each of 2 different specialties):

Course	*Credits*	*Quarter*	*Year*	***Grade*** (to be filled in by department advising staff)

Analytical, Choose 3 courses from a sequence:

Course	*Credits*	*Quarter*	*Year*	***Grade*** (to be filled in by department advising staff)

Please provide approval signatures below and return to the Graduate Programs Office:

Student's Signature_____ Date: _____

Advisor's Signature_____ Date _____

Graduate Committee Approval_____ Date: _____

SAMPLE MSAA PROGRAM PLANS

Interest Area	**Depth** Choose 8 or 5+ Thesis	**Breadth** choose 1 course in each of 2 different specialties	**Analytical** choose 3 from a sequence
FLUIDS	AA 503 AA 504 AA 506 AA 507 AA 508 AA 543 AA 544 ME 538 ME 543 ME 544	AA 530 or 540, or any Structures course AA 571 or 447* or any Controls course AA 405, 529, or any Plasma Science course AA 554 (Cross-disciplinary, countable as either a Structures or Controls course) AA 513 (Cross-disciplinary, countable as a Plasma Science course). AA 527 (Cross-disciplinary)	AMATH 501or 581 or 582 or 584 **and** AMATH 502, 503 or AMATH 567**, 568, 569
Gas Dynamics	AA 501		
Propulsion & Energy Conversion	AA 524, 525		
STRUCTURES	AA 503 AA 530 AA 531, 532 AA 534 AA 535 AA 538 ME 559 ME 560 ME 588	AA 501, 504, 524, 543, or any Fluids course AA 447*, 516, 547, 571 or any Controls course AA 405, 529, or any Plasma Science course AA 513 (Cross-disciplinary, countable as either a Fluids or Plasma Science course)	AMATH 581 or 582 or 584 **and** AMATH 502, 503
Solid Mech / Structures	AA 540, 541		
Structural Mechanics	AA 553	IND E 526 AA 527 (Cross-disciplinary)	

*AA447 is not allowable as a breadth option for students with a BS in A&A from the UW.
**With advisor approval.

SAMPLE MSAA PROGRAM PLANS *cont.*

Interest Area	Depth Choose 8 or 5+ Thesis	Breadth choose 1 course in each of 2 different specialties	Analytical choose 3 from a sequence
CONTROLS	AA 516 AA 518 AA 528 AA 546 AA 547 AA 548 AA 549 AA 550 AA 571 or ME588 AA 578 AA 580 AA 582 AA 583 AA 585 AA 593 AA 594 AA 597 Most graduate coursework in Signals and Systems	AA 501, 543 or any Fluids course AA 513, 529 or any Plasma Science course AA 530, 540, 554, 553 or any Structures course AA 527 (Cross-disciplinary)	AMATH 501, 502, 503 or AMATH 501or 581 or 582 or 584 **and** AMATH 585, 586 or AMATH 567**, 568, 569 For prospective PhD Students: AA 510, AMATH 568, 569 Optional: AA 570, 597, EE 505, AMATH 507
PLASMA SCIENCE	AA 405 AA 523 AA 529 AA 545 AA 556 AA 557 AA 558 AA 560 AA 564 AA 565 ESS 577, 578 PHYS 513, 514, 515, 543	AA 501, 543 or any Fluids course AA 513 (Cross-disciplinary, counts as a Fluids course) AA 530, 540 or any Structures course AA 447*, 571, or any Controls course AA 527 (Cross-disciplinary)	AMATH 501or 581 or 582 or 584 **and** AMATH 502, 503 or AMATH 567**, 568, 569 or AMATH 570, 571, 572

*AA 447 is not allowable as a breadth option for students with a BS in A& A from the UW.
**With advisor approval.

Doctor of Philosophy (PhD) Degree

Direct Path to PhD
Students with a bachelors' degrees in aerospace or mechanical engineering or related fields may choose to enter the PhD program on the Direct Path to PhD. Completion of the MSAA course curriculum is required (five courses in a depth area, courses in two different breadth areas, and three analytical courses) while students commence research with a faculty advisor; however, no MS thesis is required, and once the course work is satisfied (and students meet the criteria stated below), they may take the PhD Qualifying Exam. Upon passing the Qualifying Exam, they would then complete three additional courses (as recommended by their research advisor), continue their research and proceed with PhD guidelines and requirements of the department and the UW Graduate School.

Postmaster's Admission to the PhD Degree Program
Admission directly into the PhD program requires a MSAA degree, preferably in aerospace or mechanical engineering. Applicants with degrees in related fields, such as the physical sciences, mathematics, or engineering fields other than aerospace or mechanical, are also considered for admission. PhD applicants must demonstrate strong scholastic ability, potential to perform and complete independent research, and the ability to contribute creatively to advanced developments in engineering. PhD applicants must identify someone on the faculty who agrees to serve as their research advisor prior to applying to the program.

PhD students can attend the University of Washington on either a full-time or part-time basis. Although there is no official online (EDGE) PhD program, courses may be taken part-time online (http://www.msaa.uw.edu/).

Following are procedures for students pursuing a doctoral degree in the Department of Aeronautics and Astronautics. The information below provides a brief summary of the University, department and Graduate School requirements. The complete formal requirements, which you are responsible for knowing, are discussed on the Graduate School home page:
http://www.grad.washington.edu/students/doctoral/index.shtml

A summary of the Graduate School Doctoral Degree requirements may be found at:
http://www.grad.washington.edu/policies/doctoral/requirements.shtml but it is not an inclusive list. Students who have questions at any time during their postmasters and PhD studies, should see the Graduate Faculty Advisor or the Manager of Graduate Programs and External Relations.

Department Qualifying Examination
The purpose of the Qualifying Exam is to evaluate students overall scholastic preparation and to assess:

- understanding of and ability to apply fundamental concepts of the discipline
- capacity for independent thought and creative problem solving
- ability to communicate orally and to respond to questions and comments
- academic potential to engage in independent research and complete a quality PhD program.

Predoctoral students must identify a faculty advisor who agrees to accept them into their research group within the first year of completing their master's degree. Students who have a master's degree must have an advisor prior to being admitted to the program.

In order to be allowed to take the Qualifying Examination, students must have a grade point average (GPA) of at least 3.40/4.00. In addition, they must have an MSAA degree or its equivalent; the latter is

subject to approval by the Graduate Committee. Students must also have a faculty member accept them into their research program. The faculty member must agree to be their thesis advisor, to supervise their PhD research, and to chair their Qualifying Exam Committee.

Qualifying Examinations are held twice a year, during the Spring and Autumn Quarters.

The Committee will be composed of three core faculty from students' research fields and one non-core faculty from outside their research field. One faculty member may be from outside the Aeronautics and Astronautics Department. Once the faculty members have agreed to serve on the Committee, their names should be provided to the Manager of Graduate Programs.

The Committee will assign students one or more journal articles, requiring additional literature review. These are not to include review articles. In addition, it is recommended that no one on the students' Committees shall have authored, co-authored, or otherwise been involved with the research reported in the article(s) so that students will be able to more freely and completely critique the work.

Within four weeks, students will submit a report on the article to the Committee for assessment and approval. This report should include a summary of the article and a discussion addressing the relevance and impact of the article's findings, placing the research into a broader context, commenting on future directions and any appropriate criticism, and discussing any other aspects suggested by the Committee. While there is no set page limit, it is expected that the report will be approximately 7 -10 pages in length.

The Committee Chair will notify students of the Committee's decision within two weeks of submission. The Committee may provide a critique and require that students submit a revision within two weeks from that time. If the revised report is deemed unsatisfactory by the Committee, students are not permitted to proceed further. If the reports are approved, students will present a brief (approximately 20 minutes) oral presentation of the report to the Committee. The presentation will follow a prescribed template that is consistent with the expected written report. This oral presentation is open to all faculty. A question and answer session follows the presentation wherein each Committee member asks a line of questions. Other attending faculty may also ask questions. The questions are not restricted to discussion of the assigned journal article and can cover <u>any</u> topic of fundamental engineering concepts. Questions covering fundamental engineering concepts are expected to represent the majority of the questions

Students will be evaluated in equal part on these three aspects:

- Written report and oral presentation,
- Oral responses to questions after the presentation,
- Oral responses to questions on fundamental engineering concepts.

Students who pass the Qualifying Exam become eligible to pursue the PhD degree program in the Department.

Supervisory Committee

Graduate students are not official doctoral students until the Dean of the Graduate School has officially appointed a Supervisory Committee. The Supervisory Committee should be established as soon as possible (but no later than one year after completing the Qualifying Exam), and should be in place at least four months prior to scheduling the General Examination. Students should select their committees, to consist of five members – three in their major area (including the chair of the Committee), and one member to bring breadth to the Committee. The fifth member of the Committee is the Graduate

School Representative (GSR), a member of the UW Graduate Faculty who represents the broad concerns of the University with respect to standards of scholarly performance and unbiased treatment of the student on doctoral supervisory committees. The GSR represents the Graduate School at all examinations, Committee meetings, etc. He or she must be from outside the A&A department; have no conflict of interest with the Committee chair(s)/students; cannot have an adjunct appointment in the A&A department (nor can he or she be from a department in which the Committee Chair has an adjunct appointment), and must be a Graduate Faculty member. The Graduate School Policy on Doctoral Supervisory Committee Roles and Responsibilities may be found at:
http://www.grad.washington.edu/policies/doctoral/committee-roles.shtml
Once the Committee members have agreed to serve on the Committee, students should provide the list to the Manager of Graduate Programs, who will have them officially appointed through the Graduate School.

When the Committee has been approved, the members will be notified via e-mail. The Registrar's Office is also notified and students' official classifications are changed to "pre-candidate."

General Examination
The General Examination is an oral exam of about two hours' duration. It begins with a presentation by the student on the anticipated area of his/her research, followed by questions from the Committee members. The purpose of this exam is to test students' background and ability to perform independent study and research in some chosen area of specialization. It is not a presentation of completed research, and students' final area of research may indeed change.

The General Examination must be taken within 12-18 months after completing the Qualifying Exam. The exam may be scheduled four months after the official establishment of the Supervisory Committee and after having completed a minimum of 60 credits at the 500 or approved 400-level or above (18 of these credits must be numerically graded).

At least three weeks prior to the exam, students will provide the members of the Committee a document outlining the proposed research. The document should include a statement of the research objectives, a review of prior and foundational work in the area, a description of the preliminary research completed, and a plan for carrying out the remaining research. The plan should include a projected timeline identifying key milestones and dates. This document should be sufficiently complete to allow the Committee to determine likelihood of success, including contingencies for possible setbacks, and the ultimate contribution of the research to the field of study. The document should be written clearly enough to be understood by faculty not versed in the field. A document of at least 20 double spaced pages is expected. The Committee will review the document and determine within one week whether candidates are prepared to take the exam. If the document is judged inadequate, the General Exam must be rescheduled to a date not earlier than one month after the original date.

When students have determined that all members (including the GSR) can attend the selected exam date and time, the "Request for General Examination" form must be submitted on-line:
https://www.grad.washington.edu/mygrad/student.htm

Students' transcripts are then evaluated to be certain that all minimum Graduate School requirements, except the dissertation and the Final Examination, have been satisfied. If there is a problem or question with the evaluation, the department will be notified. Occasionally, a contingency will be noted, in which case Candidacy is not conferred until the contingency is satisfied. Full or part-time registration is required for the quarter when the General Examination is taken and Candidacy is awarded.

Upon passing this exam, students are given the official rank of "Candidate." If they do not pass, at the discretion of the Committee, they will either be allowed to retake the exam or will be dropped from the PhD program.

A letter of certification and a Candidate Certificate are sent to Candidates. The first, with the Dean of the Graduate School's signature, should be received within a few weeks after the end of the quarter. The second will be received from the Graduation Office at the end of the following quarter (approximately 3 months after candidacy is conferred), and the Candidacy will be posted to their transcripts after the end of the quarter in which it is conferred.

Completion of Course Work

The department requires at least 18 graded credits of course work. A PhD Program Plan form with a listing of the courses to be taken must be approved by students' supervisors and placed in their file. The form is online here: http://www.aa.washington.edu/academics/documents/phd_program.pdf
The Graduate School requires that a minimum cumulative GPA of 3.0 is maintained by graduate students.

Preparation of the Dissertation

The dissertation requires a substantial effort, and must demonstrate original and independent research and achievement. Students should consult the Graduate School Style and Policy Manual for Theses and Dissertations for instructions on appropriate format:
http://www.grad.washington.edu/students/thesis-dissertation/format-guidelines/index.shtml
and the Thesis/Dissertation Checklist for guidelines for submission of their dissertations:
http://www.grad.washington.edu/students/thesis-dissertation/checklist.shtml

Reading Committee

As students near completion of their dissertations, and before scheduling their Final Examinations, they must select a Reading Committee to read their dissertations. This Committee should include three (sometimes four) members from their Supervisory Committees. Give their names to the Manager of Graduate Programs and they will be officially appointed through the Graduate School. The members will be notified of this appointment via an e-mail confirmation from the Graduate School. Students must allow their Reading Committee at least two weeks to read their dissertation prior to scheduling the Final Exam.

Final Examination

The Final Examination is a presentation and defense of the dissertation. There should only be minor, if any, changes in the dissertation at this time. When students have determined that all members (including the GSR) can attend their selected exam date and time, a Request for Final Examination form must be submitted on-line: https://www.grad.washington.edu/mygrad/student.htm
Full or part-time registration is required for the quarter when the Final Examination is taken and the degree is awarded.

The dissertation (along with the receipt for binding and microfilming fees) must be submitted to the Graduate School. This must be done by the last day of the quarter in which students expect to complete their degrees. Students who have only minor edits to their dissertations may be eligible for the Graduate Registration Waiver Fee, if they were registered in the prior quarter, and their final exam has been taken; this allows them to graduate the following quarter without being registered. Students pay a $250 fee and must submit their dissertations two weeks following the quarter in which all Graduate School and graduate program degree requirements were met:
https://www.grad.washington.edu/area/regwaiver.html

Earned Credits Requirements

Doctoral students are required to earn 90 credits (a master's degree from the UW or another institution may be used as a substitute for 30 of these credits; however, 60 must be earned at the University of Washington). A minimum of 18 credits must be numerically graded, and completed at the UW from course work at the 500 (and approved 400) level and above. Sixty credits (including the 18 graded credits and at least 18 credits at the 500 level) must be completed prior to scheduling the General Exam. In addition, a minimum of 27 dissertation credits (AA 800) taken over a period of at least three quarters must be completed prior to graduation. Graduate students must maintain a cumulative GPA of at least 3.0.

All work toward the doctoral degree, including applicable work from the Master's degree, and time on leave or out of status, must be completed within 10 years.

Requests for exceptions to department procedures will be determined on a case-by-case basis by the Department of Aeronautics and Astronautics Graduate Committee. Requests for exceptions to University of Washington policies must be petitioned to the Dean of the Graduate School.

POLICY ON ACADEMIC PERFORMANCE

PURPOSE
To define acceptable and unacceptable academic performance and to outline the review procedure and consequences of low scholarship in the Master's and PhD programs in the Department of Aeronautics and Astronautics.

SCOPE
All graduate students in the Department of Aeronautics and Astronautics.

POLICY
Students may continue in graduate degree programs as long as they maintain satisfactory performance as well as satisfactory progress toward completion of their programs. Master of Science in Aeronautics and Astronautics (MSAA), Master of Aerospace Engineering (MAE), Master of Aerospace – Composite Materials and Structures (MAE-CMS), and Doctor of Philosophy (PhD) students must maintain a minimum cumulative grade point average (GPA) of 3.0 each quarter they are enrolled. Students must also receive a minimum grade of 2.7 for any individual course to be counted toward the graduate degree.

Each quarter, the Department receives a Low Scholarship list from the Graduate School identifying students whose quarterly GPA and/or cumulative GPA falls below 3.0. The Department Graduate Committee will review the academic records of these students, and recommend one of the following actions as outlined below:

- No formal action will be taken for a students whose names appears on this list because their QUARTERLY GPAs are below 3.0, unless the condition is caused by anomalies that require immediate advising (e.g., a student receives a grade of 0.0 in a course), in which case **they may be placed on academic probation**. The Graduate Program Advisor (and/or their faculty advisors) will notify students of the low scholarship, and will be available to help them develop a plan to rectify the problem.

- Student whose names appear on this list because their CUMULATIVE GPAs are below 3.0 for the quarter **will be placed on academic probation** by the Department. Students are encouraged to meet with the Graduate Program Advisor (and/or their faculty advisors) to discuss and agree on a plan and timeline for academic improvement. This probationary status will be recorded by the Registrar, but will not appear on the students' transcripts.*

- Students whose names appear on the low scholarship list a second time because their CUMULATIVE GPAs are below 3.0 will be placed on **final academic probation**. This final probationary status will be recorded by the Registrar, but will not appear on the students' transcripts.*

- Students whose names appear on the low scholarship list for a third time because their CUMULATIVE GPAs are below 3.0 **will be dropped from the Department.**

*Students may appeal such changes of status to the Chair of the Department of Aeronautics and Astronautics. Students may appeal beyond this point to the Graduate School for informal resolution, and if still not satisfied, may file a formal complaint with the Dean of the Graduate School.

Rev. 6/11

COURSE DESCRIPTIONS

A A 198 Special Topics in Aeronautics and Astronautics (1-5, max. 10) NW

Introduces the field of Aeronautics and Astronautics. Topics include aircraft flight, rocket propulsion, space travel, and contemporary space missions. May include hands-on activities. For non-majors.

A A 210 Engineering Statics (4) NW

Applies vector analysis to equilibrium of rigid body systems and subsystems. Includes force and moment resultants, free body diagrams, internal forces, and friction. Analyses basic structural and machine systems and components. Prerequisite: either MATH 126 or MATH 136; PHYS 121; recommended: graphics background. Offered: A,W,Su.

A A 260 Thermodynamics (4) NW

Introduction to the basic principles of thermodynamics from a macroscopic point of view. Emphasis on the First and Second Laws and the State Principle, problem solving methodology. Prerequisite: either CHEM 140, CHEM 142, CHEM 144, or CHEM 145; either MATH 126, MATH 129, or MATH 136; PHYS 121. Offered: Sp,Su.

A A 299 Undergraduate Research (1-5, max. 10)

Research on special topics under the supervision of a faculty member. Application of fundamentals learned in the classroom to real problems in research. Offered: AWSpSu.

A A 301 Compressible Aerodynamics (4)

Aerodynamics as applied to the problems of performance of flight vehicles in the atmosphere. Kinematics and dynamics of flow fields. Thin airfoil theory; finite wing theory. Compressible fluids; one-dimensional compressible flow; two-dimensional supersonic flow. Prerequisite: CHEM E 260. Offered: W.

A A 302 Incompressible Aerodynamics (4)

Aerodynamics as applied to the problems of performance of flight vehicles in the atmosphere. Kinematics and dynamics of flow fields; incompressible flow about bodies. Thin airfoil theory; finite wing theory. Prerequisite: PHYS 123; either AMATH 351, MATH 136, or MATH 307. Offered: Sp.

A A 310 Orbital and Space Flight Mechanics (4)

Newton's law of gravitation. Two-body problem, central force motion, Kepler's laws. Trajectories and conic sections. Position and velocity as functions of time. Orbit determination and coordinate transformations. Rocket dynamics, orbital maneuvers, Hohmann transfer. Interplanetary trajectories, patched conics. Planetary escape and capture. Gravity assist maneuvers. Prerequisite: M E 230. Offered: A.

A A 311 Atmospheric Flight Mechanics (4)

Applied Aerodynamics, aircraft flight "envelope," minimum and maximum speeds, climb and glide performance. Range and endurance, take-off and landing performance, using both jet and propeller power plants. Longitudinal and dynamic stability and control, wing downwash, stabilizer and elevator effectiveness, power effects. Lateral and directional stability and control. Offered: A.

A A 312 Structural Vibrations (4)

Vibration theory. Characteristics of single and multidegree-of-freedom linear systems with forced inputs. Approximate methods for determining principal frequencies and mode shapes. Application to simple aeroelastic problems. Prerequisite: M E 230. Offered: W.

A A 320 Aerospace Instrumentation (3)

Hands-on laboratory experience in aerospace instrumentation. Students build sensors, power supplies, and circuits. Application of signal conditioning to wind tunnel data. Digital systems, A/D conversion, D/A conversion, and actuator control. Introduction to instrumentation requirements for space vehicles. Offered: A.

A A 321 Aerospace Laboratory I (3)

The design and conduct of experimental inquiry in the field of aeronautics and astronautics. Laboratory experiments on supersonic flow, structures, vibrations, material properties, and other topics. Theory, calibration, and use of instruments, measurement techniques, analysis of data, report writing. Offered: W.

A A 322 Aerospace Laboratory II (3)

The design and conduct of experimental inquiry in the field of aeronautics and astronautics. Laboratory experiments on subsonic aerodynamics, supersonic flow, structures, propulsion, and other topics. Theory, calibration, and use of instruments, measurement techniques, analysis of data, report writing. Offered: Sp.

A A 331 Aerospace Structures I (4)

Analysis and design of aerospace structures. Review of concepts of stress, deformation, strain, displacement and equations of elasticity. Applications to aerospace structural elements including general bending and torsion of rods and beams, and open and closed thin-walled structures and box beams. Prerequisite: CEE 220. Offered: W.

A A 332 Aerospace Structures II (4)

Bending of plates and shells. Buckling analysis. Energy principles and minimum potential energy. Introduction to the finite element method. Airworthiness and airframe loads. Strength and damage characteristics of ductile, brittle and composite materials. Elements of fracture mechanics and fatigue. Prerequisite: A A 331. Offered: Sp.

A A 360 Propulsion (4)

Study of the aero- and thermodynamics of jet and rocket engines. Air-breathing engines as propulsion systems. Turbojets, turbofans, turboprops, ramjets. Aerodynamics of gas-turbine engine components. Rocket vehicle performance. Introduction to space propulsion. Prerequisite: A A 301. Offered: Sp.

A A 400 Gas Dynamics (3)

Introduction to kinetic theory and free molecule flow. Review of thermodynamics. One-dimensional gas dynamics: one-dimensional wave motion, combustion waves. Ideal and real gas application. Prerequisite: PHYS 123; CHEM E 260. Offered: W.

A A 402 Fluid Mechanics (3)

Inviscid equations of motion, incompressible potential flows, small perturbation flows, bodies of revolution, viscous equations, exact solutions, laminar boundary-layer equations, similar solutions, integral methods. Compressibility, instability, turbulent boundary layers. Prerequisite: MATH 324; AA 301. Offered: A.

A A 405 Introduction to Aerospace Plasmas (3)

Development of introductory electromagnetic theory including Lorentz force and Maxwell's equations. Plasma description. Single particle motions and drifts in magnetic and electric fields. Derivation of plasma fluid model. Introduction to plasma waves. Applications to electric propulsion, magnetic confinement, and plasmas in space and Earth's outer atmosphere. Prerequisite: PHYS 123; MATH 324. Offered: A.

A A 410 Aircraft Design I (4-)

Conceptual design of a modern airplane to satisfy a given set of requirements. Estimation of size, selection of configuration, weight and balance, and performance. Satisfaction of stability, control, and handling qualities requirements. Offered: W.

A A 411 Aircraft Design II (4)

Preliminary design of a modern airplane to satisfy a given set of requirements. Estimation of size, selection of configuration, weight and balance, and performance. Satisfaction of stability, control, and handling qualities requirements. Prerequisite: A A 410. Offered: Sp.

A A 419 Aerospace Heat Transfer (3)

Fundamentals of conductive, convective, and radiative heat transfer with emphasis on applications to atmospheric and space flight. Prerequisite: PHYS 123; MATH 307. Offered: W.

A A 420 Spacecraft and Space Systems Design I (4-)

Design of space systems and spacecraft for advanced near-Earth and interplanetary missions. Astrodynamics, space environment, space systems engineering. Mission design and analysis, space vehicle propulsion, flight mechanics, atmospheric entry, aerobraking, configuration, structural design, power systems. thermal management, systems integration. Oral presentations and report writing. Design topics vary. Offered: W.

A A 421 Spacecraft and Space System Design II (4)

A continuation of 420. Course content varies from year to year and is dependent on the design topic chosen for 420. Prerequisite: A A 420. Offered: Sp.

A A 430 Finite Element Analysis in Aerospace (3)

Introduction to the finite element method and application. One-, two-, and three-dimensional problems including trusses, beams, box beams, plane stress and plane strain analysis, and heat transfer. Use of finite element software. Prerequisite: CEE 220. Offered: A.

A A 432 Composite Materials for Aerospace Structures (3)

Introduction to analysis and design of aerospace structures utilizing filamentary composite materials. Basic elastic properties and constitutive relations of composite laminates. Failure criteria, buckling analysis, durability, and damage tolerance of composite structures. Aerospace structure design philosophy and practices. Prerequisite: A A 332. Offered: W.

A A 440 Flight Mechanics I (3)

Calculation of aerodynamic characteristics of aircraft and components including stability derivatives. Relation to wind tunnel and flight data. Vehicle equations of motion within the atmosphere, characteristics of propulsion systems and components including propellers. Prediction of performance, stability and control characteristics for a specific aircraft. Offered: W.

A A 441 Flight Test Engineering (3)

Determination in flight of performance, stability, and control characteristics of aircraft; and comparison with predicted and wind tunnel results. Prerequisite: A A 311. Offered: Sp.

A A 447 Control in Aerospace Systems (4)

Overview of feedback control. Linearization of nonlinear models. Model properties: stability, controllability, observability. Dynamic response: time and frequency domain techniques. Frequency response design techniques. Design of aerospace control systems via case studies. Prerequisite: M E 230; MATH 308. Offered: A.

A A 448 Control Systems Sensors and Actuators (3)

Study of control systems components and mathematical models. Amplifiers, DC servomotors, reaction mass actuators. Accelerometers, potentiometers, shaft encoders and resolvers, proximity sensors, force transducers, piezoceramic materials, gyroscopes. Experimental determination of component models and model parameters. Two 3-hour laboratories per week. Prerequisite: either A A 447 or E E 447. Offered: jointly with E E 448; W.

A A 449 Design of Automatic Control Systems (4)

Design problems for aerospace vehicles, systems with unstable dynamics, lightly damped modes, nonminimum phase, nonlinear dynamics. Computer-aided analysis, design, and simulation, with laboratory hardware-in-the-loop testing. Team design reviews, oral presentations. Prerequisite: either A A 448 or E E 448. Offered: jointly with E E 449; Sp.

A A 461 Advanced Airbreathing Propulsion (3)

Physical characteristics and components of rockets. Nozzle gasdynamics and non-ideal flow effects. Solid and liquid propulsion systems, components, and design. Aerodynamics of airbreathing engine components: inlets, compressors, turbines, afterburners, nozzles. Engine design methodology. Prerequisite: A A 360. Offered: A.

A A 462 Rocket Propulsion (3)

Covers the physical and performance characteristics of chemical rocket propulsion systems. Includes combustion chamber thermochemistry, propellant properties and handling, and rocket system component interactions.. Offered: Sp.

A A 470 Systems Engineering (4)

Concepts of system approach, system hierarchies, functional analysis, requirements, trade studies, and other concepts used to define and integrate complex engineering systems. Introduction to risk analysis and reliability, failure modes and effects analysis, writing specifications, and lean manufacturing. Offered: jointly with IND E 470; A.

A A 480 Systems Dynamics (3)

Equations of motion and solutions for selected dynamic problems; natural frequencies and mode shapes; response of simple systems to applied loads. Prerequisite: A A 312. Offered: Sp.

A A 496 Undergraduate Seminar (1, max. 4)

Lectures and discussions on topics of current interest in aviation and space technology by guest speakers. Topics vary. Offered: W.

A A 498 Special Topics (1-5, max. 15)

Topics of current interest in the department of Aeronautics and Astronautics.

A A 499 Undergraduate Research (1-5, max. 10)

Research on special topics under the supervision of a faculty member. Application of fundamentals learned in the classroom to real problems in research. A maximum of 6 credits may be applied toward senior technical electives. Offered: AWSpS.

GRADUATE COURSES

A A 501 Physical Gasdynamics I (3)

Equilibrium kinetic theory; chemical thermodynamics; thermodynamic properties derived from quantum statistical mechanics; reacting gas mixtures; applications to real gas flows and gas dynamics. Offered: even years; A.

A A 503 Continuum Mechanics (3)

Reviews concepts of motion, stress, energy for a general continuum; conservation of mass, momentum, and energy; and the second law; constitutive equations for linear/nonlinear elastic, viscous/inviscid fluids, and general materials; and examples/solutions for solid/fluid materials. Offered: jointly with M E 503; A.

A A 504 Compressible Fluid Mechanics (3)

Reviews the fundamentals with application to external and internal flows; supersonic flow, 1D and Quasi-1D, steady and unsteady flow, oblique shocks and expansion waves, linearized flow, 2D flow, method of characteristics; and transonic and hypersonic flow. Prerequisite: A A 503. Offered: Sp.

A A 506 Vortex-Dominated Flows (3)

Examines the vorticity equation, baroclinic torque, solenoidality, Biot-Savart's formula, diffusion of vorticity, Burger vortex, system of vortices, Kelvin-Helmholtz instability, effects of density, shear and surface tension on instability, swirling flows, and other special topics. Prerequisite: A A 503. Offered: even years; Sp.

A A 507 Fluid Mechanics (3)

Covers inviscid and viscous incompressible flows, exact solutions of laminar flows, creeping flows, boundary layers, free-shear flows, vorticity equation and introduction to vortex dynamics. Offered jointly with ME 507; W.

A A 508 Turbulence (3)

The phenomena of turbulence; transition prediction; Reynolds stresses; turbulent boundary-layer equations. Approximate methods for turbulent boundary layers. Prerequisite: A A 507 or permission of instructor. Offered: odd years; Sp.

A A 510 Mathematical Foundations of Systems Theory (4)

Mathematical foundations for system theory presented from an engineering viewpoint. Includes set theory; functions, inverse functions; metric spaces; finite dimensional linear spaces; linear operators on finite dimensional spaces; projections on Hilbert spaces. Applications to engineering systems stressed. Prerequisite: graduate standing or permission of instructor. Offered: jointly with CHEM E 510/E E 510/M E 510; A.

A A 513 Gas Laser Theory and Practice (3)

Physics and fluid mechanics of gas lasers, with emphasis on performance of gas dynamic lasers, flowing chemical lasers, and gaseous electric lasers. Development of laser optics, interaction of radiation and matter, laser oscillation conditions, and methods of obtaining population inversions. Applications of high-power lasers emphasized. Offered: even years; Sp.

A A 516 Stability and Control of Flight Vehicles (3)

Static and dynamic stability and control of flight vehicles in the atmosphere. Determination of stability derivatives. Effects of stability derivatives on flight characteristics. Flight dynamic model. Responses to control inputs and external disturbances. Handling qualities. Control system components, sensor characteristics. Stability augmentation systems. Offered: A.

A A 518 Automatic Control of Flight Vehicles (3)

Specifications of flight vehicle performance. Synthesis of stability augmentation systems and autopilot control laws in the frequency-domain and using multivariable control methods. Reduced-order controller synthesis, digital design, and implementation. Use of computer-aided control design packages. Prerequisite: A A 516 and A A 548. Offered: odd years; Sp.

A A 523 Special Topics in Fluid Physics (3)

Offered: A,W,Sp.

A A 524 Aeroacoustics (3)

Reviews fundamental concepts of acoustics which include sound measurements, reflection, resonance, transmission, radiation, scattering, diffraction, ray acoustics, wave guide, turbo-machinery noise, sound suppression, jet noise, and airframe noise and acoustic problems in rockets and other propulsion systems. Offered: odd years; A.

A A 525 Special Topics in Advanced Airbreathing Engines (3)

Reviews fundamental concepts of advanced airbreathing engines including advanced gas turbines, ramjets, scramjets and variants, detonation engines, flow with chemical energy release, shock dynamics, Chapman-Jouget model, ZND model, multi-cellular and spinning detonation. Offered: even years; W.

A A 527 Space Power Systems (3)

Explores the theoretical background and technology of power systems for satellites, space science missions, and planetary and lunar outposts. Focuses on photovoltaic, solar-thermal, and nuclear systems, as well as chemical systems for storage. Addresses thermal management. Offered: even years; A.

A A 528 Spacecraft Dynamics and Control (3)

Examines spacecraft dynamics and control. Includes basic orbital mechanics-the restricted three body problem, Hill's theory, perturbation theory, orbit determination, rigid body kinematics and dynamics, attitude control, and spacecraft formation flying. Prerequisite: MATH 307; MATH 308. Offered: odd years; W.

A A 529 Space Propulsion (3)

Nucleonics and heat transfer of nuclear-heated rockets. Electrothermal, electromagnetic, and electrostatic thrusters. Power/propulsion systems. Prerequisite: permission of instructor. Offered: odd years; Sp.

A A 530 Mechanics of Solids (3)

General concepts and theory of solid mechanics. Large deformations. Behavior of elastic, viscoelastic, and plastic solids. Linear theory of elasticity and thermo elasticity. Wave propagation in solids. Offered: A.

A A 531 Integrity of Metallic Aircraft Structures (3)

Examines the theory of failure for metallic structures; fatigue properties, fatigue load spectrum, fatigue crack propagation, fracture mechanics, damage tolerance, fretting and corrosion fatigue, design applications, and case studies. Prerequisite: AA 530 or equivalent or permission of instructor. Offered: odd years; W.

A A 532 Mechanics of Composite Materials (3)

Analyses and design of composite materials for aerospace structures. Micromechanics. Anisotropic elasticity. Laminated plate theory. Thermo-viscoelastic behavior and fracture of composites. Prerequisite: Undergraduate coursework in mechanics of materials or permission of instructor. Offered: W.

A A 533 Materials and Processing Technology of Aerospace Composites (3)

Covers the fundamentals of composite materials manufacturing and processing, emphasizing modern aviation industry practices. Focuses on autoclave and out-of-the-autoclave processing of carbon fiber composites, mechanical and physical property testing, generation of material allowable, and material qualification for composites. Emphasis is on aircraft structures, but is applicable to all high performance, lightweight structures. Prerequisite: none. Recommended to be taken in conjunction with AA 532. Offered: W.

A A 534 Integrity of Composite Aircraft Structures (3)

Concepts of certification by analysis supported by test evidence in aircraft structures, emphasizing regulatory agency requirements and industry approaches. Subjects include allowables approach, bolted and bonded joints, damage resistance and tolerance, specialized test methods, and inspection techniques. Prerequisite: AA 432 or AA 532 required; AA 533 recommended. Offered: Sp.

A A 535 Analysis and Design of Composite Structures (3) – New course, not yet in General Catalog

Design methodology for aerospace structures made of fiber reinforced composites; design for manufacturing; preliminary design process; detail design process; computer aided modeling and design of composite parts; examples of aerospace composite structural design and case studies. Prerequisites: AA 432 or equivalent. Offered: Sp.

A A 538 Introduction to Structural Optimization (3)

Includes the formulation of engineering design problems as optimization problems, gradient based numerical optimization methods, design oriented structural analysis, structural sensitivity analysis, approximation concepts, and introduction to multidisciplinary design optimization. Prerequisite: coursework in structural analysis; finite elements; and computer programming; or permission of instructor. Offered: odd years; A.

A A 540 Finite Element Analysis I (3)

Formulation of the finite element method using variational and weighted residual methods. Element types and interpolation functions. Application to elasticity problems, thermal conduction, and other problems of engineering and physics. Offered: W.

A A 541 Finite Element Analysis II (3)

Advanced concepts of the finite element method. Hybrid and boundary element methods. Nonlinear, eigenvalue, and time-dependent problems. Prerequisite: A A 540 or permission of instructor. Offered: Sp.

A A 543 Computational Fluid Dynamics (3)

Numerical discretization of the inviscid compressible equations of fluid dynamics. Finite-Difference and Finite-Volume Methods. Time integration, iterative methods, explicit and implicit algorithms. Consistency, stability, error analysis and properties of numerical schemes. Grid generation. Applications to the numerical solution of model equations and the 2D Euler equations. Offered: W.

A A 544 Turbulence Modeling and Simulation (3)

Numerical discretization of the incompressible Navier-Stokes equations. Projection method. Introduction to turbulence. Reynolds Averaged Navier-Stokes Equations. Algebraic, One-equation and Two-equation turbulence models. Large-eddy simulation. Direct numerical simulation. Applications to the numerical solution of laminar and turbulent flows in simple geometries. Offered: Sp.

A A 545 Computational Methods for Plasmas (3)

Develops the governing equations for plasma models - particle, kinetics, and MHD. Applies the governing equation to plasma dynamics through the PIC method and integration of fluid evaluation equations. Examines numerical solution to equilibrium configurations, and linear stability by energy principle and variational method. Prerequisite: A A 405 or A A 557. Offered: odd years; Sp.

A A 546 Advanced Topics in Control System Theory (3)

Topics of current interest for advanced graduate students with adequate preparation in linear and nonlinear system theory. Prerequisite: permission of instructor. Offered: when adequate enrollment develops prior to close of advance registration.

A A 547 Linear Systems Theory (4)

Linearity, linearization, finite dimensionality, time-varying vs. time-invariant linear systems, interconnection of linear systems, functional/structural descriptions of linear systems, system zeros and invertibility, linear system stability, system norms, state transition, matrix exponentials, controllability and observability, realization theory. Prerequisite: either A A 447, E E 447 or M E 471. Offered: jointly with E E 547/M E 547; A.

A A 548 Linear Multivariable Control (3)

Introduction to MIMO systems, successive single loop design comparison, Lyapunov stability theorem, full state feedback controller design, observer design, LQR problem statement, design, stability analysis, and tracking design. LQG design, separation principle, stability robustness. Prerequisite: A A 547/E E 547/M E 547. Offered: jointly with M E 548/E E 548; W.

A A 549 State Estimation and Kalman Filtering (3)

Fundamentals of state estimation for linear and nonlinear systems. Discrete and continuous systems. Probability and stochastic systems theory. Models with noise. Kalman-Bucy filters, extended Kalman filters, recursive estimation. Numerical issues in filter design and implementation. Recommended: AA/EE/ME 547; Offered: jointly with M E 549/E E 549. Offered: odd years, Sp.

A A 550 Nonlinear Optimal Control (3)

Calculus of variations for dynamical systems, definition of the dynamic optimization problem, constraints and Lagrange multipliers, the Pontryagin Maximum Principle, necessary conditions for optimality, the Hamilton-Jacobi-Bellman equation, singular arc problems, computational techniques for solution of the necessary conditions. Prerequisite: graduate standing; recommended: A A 548, E E 548, or M E 548. Offered: jointly with E E 550/M E 550; odd years; A.

A A 553 Vibrations of Aerospace Systems (3)

Continuous and discrete systems, natural frequencies, and modal analysis; forced vibrations and motion-dependent forces. Structural damping; control augmented structures. Measurements for structural dynamic testing. Prerequisite: A A 571 or equivalent. Offered: odd years; Sp.

A A 554 Aeroelasticity (3)

Static and dynamic aeroelasticity, unsteady aerodynamics, aeroservoelastic modeling, and active control. Offered: even years; Sp

A A 556 Space and Laboratory Plasma Physics (3)

Discussion of waves, equilibrium and stability, diffusion and resistivity, basic plasma kinetic theory, and wave-particle interactions. Prerequisite: either A A 405, ESS 515, or GPHYS 505, or permission of instructor. Offered: jointly with ESS 576; W.

A A 557 Physics of Fusion Plasmas (3)

Review and comparison of single particle and fluid descriptions of plasmas. MDH equilibrium, flux surfaces, and basic toroidal description. Collisional processes including physical and velocity space diffusion. Introduction to island formation, stochasticity, and various plasma instabilities. Prerequisite: A A 405 or GPHYS 505. Offered: even years; W

A A 558 Plasma Theory (3)

Equilibrium, stability, and confinement. Classical transport, collisionless and resistive skin depths. Ideal MHD equations formally derived and properties of plasmas in the ideal limit are studied. Straight and toroidal equilibrium. Linear stability analysis with examples. Taylor minimum energy principle. Prerequisite: either A A 405, A A 556, A A 557, ESS 576, or GPHYS 537. Offered: even years; Sp.

A A 559 Plasma Science Seminar (1, max. 10)

Current topics in plasma science and controlled fusion with presentations by invited speakers, on-campus speakers, and students. Students expected to give a seminar once or twice a year with instructor reviewing the method of presentation and material used for the presentation. Credit/no credit only. Offered: A,W,Sp.

A A 560 Plasma Diagnostics (3)

Discusses plasma measurement methods including material probes and optical methods. Covers techniques for making measurement in a high electrical noise environment. Presents methods for measuring electron and ion temperatures, density, impurities, magnetic fields, fluctuations, and neutrals. Prerequisite: A A 405 or equivalent. Offered: even years, A.

A A 564 Kinetic Theory/Radiative Transfer (3)

Boltzmann and Collisionless Boltzmann (Vlasov) equations. Instabilities in homogeneous and inhomogeneous plasma, quasi-linear diffusion, wave-particle interaction, collisional (Fokker-Plank) equation. Introduction to radiative non-equilibrium, scattering and absorption processes. Integral equation of radiative transfer. Prerequisite: A A 501 or permission of instructor. Offered: even years; Sp.

A A 565 Fusion Reactor Fundamentals (3)

Introduction to basic engineering features of fusion power plants. Brief description of basic fusion physics and discussion of power plants for leading thermonuclear concepts. Engineering problems; blanket, shield neutronics; materials, thermal hydraulics; tritium, superconducting systems. Prerequisite: completion of or concurrent enrollment in A A 405 or permission of instructor. Offered: odd years; W.

A A 570 Manifolds and Geometry for Systems and Control (3)

Introduction to fundamentals of calculus on manifolds and group theory with applications in robotics and control theory. Topics include: manifolds, tangent spaces and bundles, Lie groups and algebras, coordinate versus coordinate-free representations. Applications from physics, robotics, and control theory. Offered: jointly with EE 570/M E 571; Offered: even years, W.

A A 571 Principles of Dynamics I (3)

Systems of particles, rotating axes, rigid-body dynamics; calculus of variations. Lagrangian mechanics. Hamilton's principle. Kane's equations. Periodic and quasiperiodic motion. Stability of dynamical systems. Offered: A.

A A 578 Optimization in System Sciences (3)

Covers convex sets, separation theorems, theorem of alternatives and their applications, convex analysis, convex functions, conjugation, subgradients, convex optimization, duality and applications, linear and semi-definite programming. Linear matrix inequalities, optimization algorithms, applications in system theory and control, bilinear, rank minimization, optimization software. Recommended: A A 547/M E 547/E E 547. Offered: jointly with E E 578/M E 578; Offered: W.

A A 580 Geometric Methods for Non-Linear Control Systems (3)

Analysis and design of nonlinear control systems focusing on differential geometric methods. Topics include controllability, observability, feedback linearization, invariant distributions, and local coordinate transformations. Emphasis on systems evolving on Lie groups and linearly uncontrollable systems Prerequisite: A A 570/E E 570/M E 570. Offered: jointly with E E 580/M E 580; even years, Sp.

A A 582 Introduction to Discrete Event Systems (3)

Modeling DES with automata and Petri nets. Languages. State estimation and diagnostics. Control specifications. Feedback control. Dealing with uncontrollability and unobservability. Dealing with blocking. Timed automata and Petri nets. Prerequisite: A A 447/E E 447/ M E 471. Offered: jointly with E E 582/M E 582; even years; Sp.

A A 583 Nonlinear Control Systems (3)

Analysis of nonlinear systems and nonlinear control system design. Phase plane analysis. Lyapunov stability analysis. Describing functions. Feedback linearization. Introduction to variable structure control. Prerequisite: A A/E E 447/M E 471. Offered: jointly with E E/M E 583; odd years, Sp.

A A 585 System Identification and Adaptive Control (3)

Theory and methods of system identification and adaptive control. Identification of linear-in-parameter systems, using recursive LS and extended LS methods; model order selection. Indirect and direct adaptive control. Controller synthesis, transient and stability properties. Prerequisite: Recommended: AA/EE/ME 547. Offered: jointly with M E 585/E E 585; even years, Sp.

A A 589 Special Topics in Solid Mechanics (3)

Offered: A,W,Sp.

A A 593 Feedforward Control (3)

Design feedforward controllers for precision output tracking; inversion-based control of non-minimum-phase systems; effect of plant uncertainty on feedforward control; design of feedforward controllers for applications such as vertical take off and landing aircraft, flexible structures and piezo-actuators. Prerequisite: A A 547/E E 547/M E 547. Offered: jointly with E E/ M E 593; even years, Sp.

A A 594 Robust Control (3)

Basic foundations of linear analysis and control theory, model realization and reduction, balanced realization and truncation, stabilization problem, coprime factorizations, Youla parameterization, matrix inequalities, H-infinity and H2 control, KYP lemma, uncertain systems, robust H2, integral quadratic constraints, linear parameter varying synthesis, applications of robust control. Prerequisite: AA547. Offered: jointly with E E 594/M E 594; odd years; Sp.

A A 595 Global Integrated Systems Engineering (4,6)

Covers systems engineering, project management, finance/economics and a seminar series on global technical topics. Offered: jointly with IND E 595; A,W.

A A 596 Global Integrated Systems Engineering (3)

Project-based systems design course. Prerequisite: AA/IND E 595. Offered: jointly with IND E 596; Sp.

A A 597 Networked Dynamics Systems (3)

Provides an overview of graph-theoretic techniques that are instrumental for studying dynamic systems that coordinate their states over a signal-exchange network. Topics include network models, network properties, dynamics over networks, formation control, biological networks, observability, controllability, and performance measures over networks. Prerequisite: A A 547/E E 547/M E 547. Offered: jointly with E E 597/M E 597.

A A 598 Special Topics in Aeronautics and Astronautics (1-5, max. 15)

Introduction of special topics in the field of aeronautics and astronautics. Topics introduced by regular and guest speakers and includes a variety of information that is of current interest in aeronautics and astronautics. Offered: A,W,Sp.

A A 599 Special Projects (1-5, max. 15)

Investigation on a special project by the student under the supervision of a faculty member. Offered: A,W,Sp,S.

A A 600 Independent Study or Research

Offered: A,W,Sp,S.

A A 700 Master's Thesis

Offered: A,W,Sp,S.

A A 800 Doctoral Dissertation

Offered: A,W,Sp,S.

jSTUDENT HOUSING INFORMATION

Accommodation at the University Of Washington
Graduate students live both on and off campus. There is family housing near campus for married students, as well. Information about on-campus housing can be found at:

Housing and Food Services
305 Schmitz Hall, Box 355842
University of Washington,
Seattle, WA 98105
(Telephone: (206) 543-4059)
http://www.hfs.washington.edu/housing/Default.aspx?id=872

Since the University of Washington is a neighborhood university, there is plenty of off-campus housing nearby. For those choosing to live farther away from campus, it is easy to commute by bike or Metro bus: http://www.kingcounty.gov/transportation.aspx

Advertisements for shared and single-occupancy housing are found posted at the University or in local papers or on-line (or by driving through nearby neighborhoods). For more information, contact the office below or go to their website:

Off-Campus Housing Affairs
218 Condon Hall
University of Washington
Seattle, WA 98195
Telephone: (206) 543-8997
http://housing.asuw.org/

CORRESPONDENCE AND INFORMATION REQUESTS ABOUT THE DEPARTMENT OF AERONAUTICS & ASTRONAUTICS SHOULD BE ADDRESSED TO:

Manager of Graduate Programs and External Relations
Department of Aeronautics & Astronautics
University of Washington Box 352400
Seattle, WA 98195-2400
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