Graduate Student Handbook

2023 / 2024 Academic Year
Effective August 1, 2024

Ann & H. J. Smead Department of Aerospace Engineering Sciences

1 Foreword

Aerospace Engineering Sciences (AES) is one of the top aerospace engineering departments in the nation.

As you progress through your graduate career in our department, we will take into consideration the impact that this pandemic has had for many of us and provide accommodations and flexibility, within reason and when necessary, to ensure your success. Please review campus- and college-wide communications regarding COVID-19, as well as the departmental newsletter, webpage, and communications from graduate academic advisors and others in the department.

CU Boulder's COVID-19 Resources:

- The Graduate School's COVID-19 FAQs
- CEAS Pass/Fail Grading Policy for Spring 2020
- CU Boulder's COVID-19 Updates
- Counseling and Psychiatric Services (CAPS)
- Office of Diversity, Equity & Community Engagement (ODECE)

3 Key Contacts

Graduate Advisors: The graduate advisors (Graduate Program Advisors, GPAs) are students' first point of

4 Academic Standards

A master's degree student is required to maintain at least a B (3.00) average in all work attempted while enrolled in the Graduate School. Admission to PhD candidacy requires a 3.25 average. For both the master's degree and PhD, a course mark below B- is unsatisfactory and will not be counted toward fulfilling the minimum requirements for the degree.

Students who wish to drop a course after the drop deadline must show that they were unable to drop the course during the posted deadlines due to documented reasons that were beyond their control. An incomplete (I) grade is given only when students, for documented reasons beyond their control, have been unable to complete course requirements in the semester enrolled. A substantial amount of work must have been satisfactorily completed before approval of such a grade is given. At the end of one year,

6 Master of Science Degree

The Master of Science (MS) in Aerospace Engineering (ASEN) is an advanced degree that aims to provide students further specialization after their Bachelor of Science degree. The MS degree in Aerospace Engineering Sciences can be obtained via two paths:

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6.3.4 Non-Thesis Course Work: Focus Area-Defined Courses

Some Focus Areas offer the option to take additional courses to satisfy the non-thesis option. This will represent at least an additional six credit hours with respect to the minimum requirement to obtain a MS with that Focus Area. The details for each Focus Area can be found in Appendix A.

6.4 Bachelor's-Accelerated Master's Program (BAM)

The Bachelor's–Accelerated Master's (BAM) degree program options offer currently enrolled CU Boulder undergraduate students the opportunity to receive a bachelor's and master's degree in a shorter period of time. You will receive the bachelor's degree first, but begin taking graduate coursework as undergraduates (during your senior year). Because some courses are allowed to double count for both the bachelor's and the master's degrees, you will earn a master's degree in less time and at a lower cost than a stand-alone master's degree program. In addition, staying at CU Boulder to pursue a bachelor's–accelerated master's program will allow you to continue working with your established faculty mentors.

***Note: There are two different BAM program options available to aerospace students.** You can choose between an MS in Aerospace Engineering Sciences or a Professional ME in Engineering Management. Information on the aerospace BAM program is below. For details on the engineering management BAM program, visit the Lockgaprogram Mre. Fpthro1 (e)-3 (SpanEMC BT/4 /MCID 53 /TT1 1 Tf220 Tw 10.967 BDC20 g-0

- June 30th - Application Closes
- Students can apply the semester before enrolling in ASEN 4018 - Senior Projects 1: Design Synthesis. For enrollment prerequisites, refer to the catalog pages.

In preparation to apply, please visit these resources:

- The Graduate School's pages contain important information for prospective and current graduate students.
- The Graduate School Rules provide detailed information on credit enrollment limits, academic probation, credit transfer rules, and other subjects.
- Eligible students may apply for the BAM program by completing the BAM Intent Form. Visit the Registrar's Office BAM page for more information.

6.4.4 Resources for Students Currently Admitted to BAM

- It is expected that all BAM and graduate students will be fully familiarized with the content of the hao49j2(o)-9.6 ()2.2 (es) (o)-6.6 (o)-6.6kto'4 -0 0 10.002 Tc (o)-6. 8S8 0 Tdo–'jk%DEE[illegible]u"0•gP[illegible]BAM Tc (o)(e)-6 (

curricular requirements in AES, you must submit a course petition for each request.

***Note: Students pursuing the ASEN BAM Program are exempt from this rule and shall abide by BAM rules, Section 6.4 of this handbook.**

7 Ph.D. Degree

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following the passing of the comprehensive exam and extending through the semester in which the dissertation is successfully defended (Doctoral Final Examination). See the Graduate School Rules for additional information.

- For the PhD, a course mark **below B- is unsatisfactory** and will not be counted toward fulfilling the minimum requirements for the degree.

In addition to these course requirements, students are expected to also pass a series of examinations. Students must pass the Preliminary Exam by their 5th semester as a CU Boulder PhD student, although most students take the exam in their 3rd semester. If a student enters the PhD program with a master's degree in Aerospace Engineering, their Faculty Advisor can require the exam be taken by their 3rd semester. Students must pass a comprehensive examination: A) no later than the end of the 5th semester if the student already has an aerospace master's degree; B) the 7th semester if the student does not already have an aerospace master's degree. **Note that students must have completed or be enrolled in the remaining courses to complete the 30 required course credit hours during this semester.** Students cannot be admitted into candidacy until the necessary coursework is complete. The Graduate School requires the accumulation of PhD dissertation credit hours within the maximum 6-year program length to complete the PhD. For additional information, see Graduate School Rules. Finally, students must complete a PhD dissertation and successfully defend the dissertation in a Doctoral Final Examination.

Doctoral degree students are expected to complete all degree requirements within six years from the semester in which they are admitted and begin course work in the doctoral program. Students who fail to complete the degree in this six-year period may be dismissed from their program with the concurrence of the faculty advisor and/or appropriate departmental personnel. To continue, the student must file a petition for an extension of the time limit with the Dean of the Graduate School. Such petitions must be endorsed by the student's faculty advisor and/or other appropriate departmental personnel and may be granted for up to one year.

7.3 Doctoral Practicum

7.3.1 Objectives

The Doctoral Practicum (DP) is a required element of the PhD program in Smead Aerospace that complements the primary research and academic experiences which are core to the awarding of a doctorate. The objective of the DP is to provide students with an experience to use their advanced education to teach, mentor, and serve as role models. The emphasis of the practicum is on using technical skills, education, and insights in service to others. The expectation is that this activity will help students grow confidence and skills as leaders. The process is formative and students are responsible for articulating how their chosen practicum will be structured toward achieving the following goals:

1. Provide meaningful educational or societal benefit/impact to others.
2. Provide intrinsic value to the student's professional or personal development.
3. Leverage the intellectual rigor consistent with the expectations conferred upon an individual who has earned their PhD.

7.3.2 Examples

Examples of acceptable DP activities include, but are not limited to:

- Participation in the GPTI or iTA program for one semester
- Team teaching a course with AES faculty member
- Participating in the MS review committeeParticipating in the applicant mentoritrog)

Each of the Oral Exam components is expected to take approximately 30 minutes with a total exam duration of up to 2 hours (allowing for an additional 30 minutes of deliberation by the committee without the student present). The Oral Exam will be scheduled by the Graduate Advising Staff during a 2 week period based upon the availability of the Preliminary Exam Committee Members. Note: due to the scheduling challenges students may be asked to accommodate the committee availability by missing classes or other commitments during this two week period, but all exams will be administered during normal business hours (i.e. 8am - 5pm, Monday - Friday).

The Oral Examination will begin with a brief 5-10 minute presentation by summarizing the literature they surveyed, highlighting the key conclusions of the work and potential directions for future research. Following this presentation, the Preliminary Exam Committee members will ask questions of the student about their literature review (written and presented). This examination and discussion will be led by the student's primary research advisor, but the remaining two committee members are also expected to participate.

Outside committee members must be approved by the Graduate School and receive a special Graduate Faculty Appointment (GFA). Consult with your Graduate Program Advisor at least one month prior to the comprehensive or thesis exam in order to request a GFA for an outside committee member, when necessary. Additional documents (e.g. CV) may be necessary to complete the request.

Professors from other departments who hold courtesy appointments in AES can be included as either internal or external members, but not both. Each student should work with their Faculty Advisor to identify suitable faculty members to serve on the committee.

The student's faculty advisor serves as the Committee Chair unless a conflict of interest or other extenuating circumstances have been identified.

7.5.3 Written Research Proposal

The written element consists of a research proposal (typically 15-20 pages, single spaced, but may be longer) that demonstrates the student's capacity for scholarly work in their chosen topic, lays out a proposed plan for the remaining research activities, and includes a timeline for the proposed research tasks. Students should d

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8 Appointments

Students can be supported by the Department with three different types of positions:

- Salary compensation, by semester, with tuition support: Research Assistant (RA) and Teaching Assistant (TA).
- Salary compensation, by semester: Teaching Facilitators (TF).
- Hourly paid positions, for research, grading, or other activities in the department.
- Additionally, students can also be supported through external fellowships, or with personal funds.

8.1 Appointment Percentage

The majority of department RA/TA/TFs have a 50% AY appointment (20 hrs/wk). Some may have summer appointments (up to 40 hrs/wk) but this is determined by the supervisor. A RA/TA can hold no less than a 15% appointment to receive tuition remission. Any appointment in addition to a 50% appointment needs s2 (p)ppoi.038ntm6.6nt)-1.9 (t)-3 (ial a(aid)2. (v)8.317o(n)-0.7 (t)-6 (n)-0.7 (e))-0.7 r-(%)l.8 .946 0y n 2 9.7 (t)-5.9 (t)-6 (r)-2.8.6

Appendix A. Focus Area Curricula

A.1 Astrodynamics and Satellite Navigation Systems (ASN)

ASN Specific MS Requirements

Three ASN Core Classes

One ASEN MS course from an outside (non-ASN) AES Focus Area. The outside course is any

AUT Course-only MS Requirements

Satisfaction of AUT Specific MS Requirements, plus two additional courses, each from a *different topic area.

*Note: Topic areas used to satisfy the AUT Specific MS Requirements can be repeated.

AUT Specific PhD Requirements

Satisfaction of the AUT Specific MS Requirements.

Elective Courses offered by AUT Focus Area:

Course Number	Course Title	Offering
ASEN 5114	Automatic Control Systems	Varies
ASEN 6519	Verification and Synthesis of Stochastic Systems	Spring

A.3 Bioastronautics (BIO)

BIO Specific MS Requirements

ASEN 5016 Space Life Sciences
ASEN 5158 Space Habitat Design

One of four:

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A.4 Fluids, Structures, and Materials (FSM)

The Fluids, Structures and Materials (FSM) Focus Area is further divided into two tracks: (1) Fluids, and (2) Structures and Materials.

FSM Specific MS Requirements

- Two Core Classes in your chosen FSM track, and one core course in the other FSM track.
- Two electives from the FSM Focus Area, with at least one in your chosen track.
- Attending 50% of the "Fluid, Structures and Materials" seminars each semester.

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Elective Courses approved by FSM Focus Area:

Fluids

Course Number	Course Title	Offering
ASEN 5053	Space Propulsion	Spring, Even years
ASEN 5121	Boundary Layers and Convection	Varies
ASEN 5519	Introduction to Hypersonics	Fall, Annually
MCEN 5022	Classical Thermodynamics	Spring, Annually
MCEN 5042	Heat Transfer	Spring, Annually
MCEN 5151	Flow Visualization	Fall, Annually
MCEN 5152	Introduction to Combustion	Fall, Annually
MCEN 5228	Computational Fluid Dynamics	Varies
MCEN 6001	Reacting Flows	Spring, Even years
ASEN 6011	Experimental Fluid Mechanics	Fall, Odd years
ASEN 6037	Turbulent Flow	Spring, Odd years
ASEN 6061	Molecular Gas Dynamics and Direct Simulation Monte Carlo	Varies
ASEN 6331	Computational Fluid Dynamics Unstructured Grid	Fall, Even years

Structures and Materials

Course Number	Course Title	Offering
ASEN 5111	Aeroelasticity	Varies
ASEN 5148	Spacecraft Design	Spring, Annually
ASEN 5218	Large Space Structures Design	Spring, Even years
ASEN 5212	Composite Structures and Materials	Spring, Odd years
ASEN 5519	Nonlinear Mechanical Vibration	Biennially
ASEN 5519	Design Optimization in Aerospace Systems	Varies
ASEN 5519	Introduction to Phononics	Biennially
ASEN 5188 (same as) EMEN 5405	Space Systems Engineering	Spring, Annually
ASEN 6107	Nonlinear Finite Elements	Varies
ASEN 6412	Uncertainty Quantification	Spring, Even years
ASEN 6519	Molecular Dynamics	Varies
CVEN 5161	Advanced Mechanics of Materials I	Check with CVEN
CVEN 6161	Advanced Mechanics of Materials II	Check with CVEN
CVEN 7141	Plates and Shells	Check with CVEN
CVEN 7511	Computational Mechanics of Solids and Structures	Check with CVEN
MCEN 5044	Mechanical Behavior of Materials	Check with MCEN
MCEN 5228	Mechanics of Composite Materials	Check with MCEN
MCEN 5228	Mechanics of Soft Materials	Check with MCEN

A.5 Remote Sensing, Earth and Space Science (RSESS)

The expected competency at the graduating masters level in the RSESS Focus Area is to have completed coursework in four primary topics of study (1) Data or Numerical Analysis Methods, (2) Instrumentation Fundamentals, (3) Physical Sciences of Earth and Space and (4) Astrodynamics and Satellite Navigation Systems (ASN):

The expected competency at the PhD level is to further advance the four primary topics within RSESS by complementary theory and analysis obtained through coursework offered at the 6000 level and above, and by research activities in developing the PhD thesis. The below requirements are applicable to both MS and PhD candidates in the RSESS Focus Area.

Required courses needed to specialize in the RSESS Focus Area are:

- One 3-credit course in data or numerical analysis methods
- One 3-credit course in instrumentation fundamentals
- One 3-credit course in physical sciences of Earth and Space
- One 3-credit course in astrodynamics or aerospace engineering systems

Note that MS students using the Remote Sensing Certificate for their degree requirements in lieu of an MS thesis or two semester graduate projects may count a maximum of 2 of the 4 required RSESS Focus Area courses toward the certificate requirement.

Below is a list of RSESS Primary courses that satisfy the four primary topics. These courses are listed here as their content satisfies a primary topic in our Focus Area. Students can design a course schedule with their graduate faculty advisor to ensure their course selections satisfy the RSESS Focus Area. It is possible

Course Number	Course Title	Offering
ECEN 5612	Random Processes for Engineers	Fall, Annually
ECEN 5632	Theory and Application of Digital Filtering	Fall, Annually
ECEN 5652		

RSESS ASN Primary Courses (4):

Course Number	Course Title	Offering
ASEN 5014	Linear Control Systems	Fall, Annually
ASEN 5044	Statistical Estimation for Dynamical System	Fall, Annually
Either ASEN 5050 or ASEN 5052*	Space Flight Dynamics Analytical Astrodynamics	Either Fall or Spring, Annually
ASEN 5051	Fundamentals of Fluid Dynamics	Fall, Annually

ASEN 5148

C.2 Certificate in Hypersonics

(Open to continuing education students)

This certificate recognizes student accomplishments at the graduate level in successfully completing a specialized program of study in the cross-disciplinary field of hypersonics. It is sponsored by the Ann and H. J. Smead Department of Aerospace Engineering Sciences (AES) and the Paul M. Rady Department of Mechanical Engineering (ME) and involves courses from AES and ME.

The purpose of the certificate is to develop interdisciplinary skills in the field of hypersonics, which requires knowledge about fundamental areas such as gas dynamics, materials, controls, and how their inter-relationships determine hypersonic vehicle performance.

Certificate Requirements

The standard requirements of this certificate program are the completion of twelve (12) credit hours of graduate-level coursework (typically four 3-credit courses).

There is one required course, ASEN 5519: Introduction to Hypersonics. Each student is free to choose the other three courses from the Electives list.

Grades of B or higher are required for fulfillment of requirements and certificate award.

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C.3 Certificate in Radio Frequency Engineering for Aerospace

(For degree–seeking students only)

A joint certificate program between Smead Aerospace and the Department of Electrical, Computer & Energy Engineering. This certificate fills an industry need in Colorado and beyond for cross disciplinary graduate level education in aerospace and electrical engineering. The program is open to new and current degree-seeking AES and ECEE students. Non-degree students cannot enroll in this program.

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C.4 Certificate in Remote Sensing

(Open to continuing education students)

Remote sensing (satellite and ground-based) is increasingly being used as a technique to probe the Earth's geospace, atmosphere, ocean and land surfaces. Probing of other planets is accomplished largely by satellite remote sensing. Given national priorities in such areas as climate and global change, the interest in remote sensing will only increase with time.

Remote sensing is a relatively new academic subject, with few universities having any sort of an organized curriculum. The purpose of formalizing the CU remote sensing curriculum is to coordinate curricula across campus so that a coherent curriculum in remote sensing can be provided to complement and supplement

Elective List

Students are required to meet course prerequisites. Questions should be directed to the course instructor. To develop cross-disciplinary breadth, students are strongly encouraged, but not required, to choose elective courses outside of their major.

ASEN 5010 Spacecraft Attitude Dynamics and Control [1]
ASEN 5050 Space Flight Dynamics [1] or ASEN 5052 Analytical Astrodynamics [1]
ASEN 5053 Space Propulsion
ASEN 5067 Microavionics: Introduction to PIC Microcontrollers for Aerospace Systems [2]
ASEN 5090 Introduction to Global Navigation Satellite Systems [1]
ASEN 5335 Aerospace Environment
ECEN 5134 Electromagnetic Radiation and Antennas
ECEN 5264 Electromagnetic Absorption, Scattering and Propagation
ECEN 5517 Power Electronics and Photovoltaic Power Systems Laboratory
ECEN 5613 Embedded System Design
ECEN 5623 Real-Time Embedded Systems
ECEN 5634 Microwave and RF Laboratory
ECEN 5692 Principles of Digital Communication
ECEN 5797 Introduction to Power Electronics
ECEN 5813 Principles of Embedded Software
EMEN 5010 Introduction to Engineering Management
EMEN 5030 Fundamentals of Project Management
EMEN 5031 Software Project Management
EMEN 5405 Fundamentals of Systems Engineering

[1] Core ASN certificate courses. Cannot be counted for both certificates.
[2] Course enrollment is limited to non-Electrical Engineering students.

C.6 Certificate in Space Weather and Applications

(Open to continuing educations students)

This certificate will provide you with interdisciplinary skills in the field of space weather of both fundamental processes in science and practical applications to space-based and ground-based technology.

Certificate Requirements

- ASEN 5335: Aerospace Environment (3 credit hours)
- Two courses from the Tier 1 Electives List (6 credit hours)
- One additional course from the Tier 2 Electives list (3 credit hours)
- At least one course must be outside the student's home department

12 credit hours total

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Electromagnetics & Plasma

ASTR 7160 Intermediate Plasma Physics (equiv. to PHYS 7160)

Data Science

Appendix D. List of Approved Certificates

D.1 Interdisciplinary Certificates

Some of the most popular certificate programs include the following.

- Astrodynamics and Satellite Navigation
- Atmospheric & Oceanic Sciences