Aerospace Engineering Sciences

GRADUATE STUDENT HANDBOOK

(AY 2006-2007)

Foreword

The Department of Aerospace Engineering Sciences at the University of Colorado is one of the top ten aerospace engineering departments in the nation. Aerospace engineers work on Earth and in space not only to extend frontiers but also to understand more fully and to preserve our terrestrial environment. Few fields offer more exciting and diverse careers: becoming an astronaut (fifteen CU graduates to date have become astronauts), designing the next generation of aircraft and spacecraft, monitoring our global habitat via remote sensing from space, and helping to develop environmentally clean energy and transportation systems.

Currently the Department of Aerospace Engineering Sciences has 27 full-time faculty, 3 research professors, 5 postdoctoral research associates, and another 8 researchers from government and industry who serve as adjoint faculty or lecturers. These support 450 undergraduates and a graduate program of 170 students.

Teaching and research address both the challenges and the opportunities facing the aerospace engineering profession today. Graduate students, research staff and faculty work together on a wide range of research topics: aerodynamics and fluid mechanics; aerospace design and system engineering; astrodynamics and orbital mechanics; atmospheric, oceanic and space sciences; bioastronautics; computational and analytic methods; global positioning technology; remote sensing; structures, materials and structural dynamics; systems and control; and thermodynamics and propulsion.

Nearby government and industrial laboratories enhance the rich research environment of the University of Colorado. Local aerospace firms or their divisions include Ball Aerospace, Lockheed-Martin, Hughes, Raytheon, Loral, and TRW. Nearby government laboratories include the National Center for Atmospheric Research (NCAR), the Environmental Research Laboratories of the National Oceanic and Atmospheric Administration (NOAA), the National Renewable Energy Laboratory (NREL), and the National Institute of Standards and Technology (NIST).

In addition to the rules set forth in this Graduate Handbook, all students are also subject to the rules and provisions required by the University of Colorado Graduate School. The Graduate School Rules appear at: http://www.colorado.edu/GraduateSchool/policies/downloads/GSRules_REV.pdf

Admission Requirements

An applicant may be admitted to the Graduate School as either a regular degree student or a provisional degree student. For acceptance into the Department of Aerospace Engineering Sciences, the following requirements must be met.

Regular Degree Students must:

1. Hold a baccalaureate degree in engineering, science, or mathematics from a college or university of recognized standing, or equivalent.
2. Show promise of ability to pursue advanced study and research, as judged by the student's previous scholastic record.
3. Have had adequate preparation to enter graduate study in the chosen field.
4. Have at least a 3.00 (B) undergraduate grade point average.
5. Have taken the GRE.

Aerospace Engineering Sciences at CU-Boulder has established minimum standards for graduate admission. Applicants must:

1. Have undergraduate courses in calculus, linear algebra, and differential equations.
2. Have two semesters of undergraduate calculus-based physics.
3. Have at least two semesters of upper-division undergraduate courses in engineering or physics.

International students must provide documentation that they have the financial resources to support themselves for at least the first year in the program.

Students with undergraduate degrees in all areas of engineering are encouraged to apply. Students with undergraduate degrees in mathematics, physics, chemistry and other physical sciences are also encouraged to apply.

In limited cases, applicants who do not meet the requirements for admission as regular degree students may be recommended for admission to the program under provisional degree status. With the concurrence of the dean

of the Graduate School, these students are admitted to a probationary term of either one or two semesters of full-time study or the equivalent for part-time students. At the end of the specified probationary period, provisional degree students must be either admitted to regular degree status or dismissed from the graduate program to which they were provisionally admitted. To be changed to regular degree status a student must maintain a 3.25 grade point average in 12 hours of graduate course work over two semesters.

Application Procedures

Graduate students are admitted into a specific focus area that provides research advising, financial support, and sets specialized admission and program requirements and recommendations for course work within and outside the department. The five focus areas are:

- Astrodynamics and Satellite Navigation Systems
- Remote Sensing, Earth and Space Science
- Vehicle Systems, including Aerodynamics, Systems and Control
- Bioastronautics
- Structural and Material Systems

Each focus area has defined the required characteristics of its successful graduates at the MS and Ph.D. level, and defined the required and elective courses that support its educational program. See, focus area curricula charts beginning on page 19.

An applicant for admission must present complete application materials that include:

1. Part I and Part II of the graduate application (including focus area/special field).

2. Two official transcripts of all academic work completed to date, sent to the dept.

3. A $50 nonrefundable application fee. The foreign application fee is $70.

4. Four letters of recommendation.

5. *Official* test scores from the analytical, quantitative, and verbal sections of the Graduate Record Examination (GRE) taken within the past 5 years.

Applicants are encouraged to submit the electronic application for admission. Application forms can also be downloaded from this website, http://www.colorado.edu/prospective/graduate/academics/engineering/aerospace.html.

The application deadline is FEBRUARY 1 for FALL semester, and OCTOBER 1 for SPRING semester. International students should apply by December 1 for FALL and August 1 for SPRING

Academic Standards

A masters 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 Ph.D. candidacy requires a 3.25 average. For both the master's degree and Ph.D., a course mark below B- is unsatisfactory and will not be counted toward fulfilling the minimum requirements for the degree.*

A student who fails to maintain a 3.00 grade point average or to make adequate progress toward completing a degree, as assessed by the student's academic/research advisor, will be subject to suspension from the Graduate School upon consultation with the major department. The final decision on suspension will be made by the dean of the Graduate School.

See the Graduate School Rules, http://www.colorado.edu/GraduateSchool/policies/downloads/GSRules_REV.pdf, for additional information.

*An incomplete failing (IF) 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, an IF grade given for a course that is not successfully completed or repeated is regarded as an F and shown as such on the student's transcript.

Students should refer to the version of the Graduate Handbook in effect at the time of their matriculation for degree plan requirements. Students who are readmitted or continue on from the MS/ME to the Ph.D. program are subject to the handbook in effect at the time of their continuation start date.

Master of Science Degree

Program Requirements:

- A total of 30 semester hours (including courses, seminars and thesis hours), at least 24 semester hours of which must be completed at the 5000 level or above, with no more than 12 semester hours outside of ASEN or 3 credit hours from seminars counted.
- Up to 6 credits can be taken at the 4000 level in related engineering, math and science departments (ECEN, CVEN, MCEN, CHEN, CSCI, ATOC, ASTR, PHYS, MCDB, APPM, MATH, CHEM, IPHY, GEOL, ENVD).
- Two to four required courses (6-12 semester hours) as defined by the student's focus area must be taken in the student's primary focus area and one required course (3 semester hours) must be taken in a second focus area.
- Two math courses (6 semester hours) in ASEN, APPM or MATH.
- Students may take an ASEN 6000 level seminar for credit only once (1 semester hour).
- Students may take an ASEN 6000 level seminar for credit (where they present research) only once (2 semester hours). Students should tell the graduate advisor that they will be presenting research so they are enrolled in the correct number of semester hours (2).
- A maximum of three ASEN seminar credits count toward the MS degree. Seminar credits earned in other disciplines do not count toward the MS degree.
- Students must fulfill a graduate project requirement (6 credit hours) consisting of either: (1) MS thesis (Plan I), (2) two semesters of independent study (Plan II), or (3) a two-semester team project course (Plan II). Each project culminates with an oral presentation and or written report or oral examination (in the case of the MS thesis). A "pass" on the MS defense or a B- or higher for both semesters of independent study or projects is required for successful completion of the MS. The MS independent study project may have a written and/or oral report requirement at the discretion of the faculty advisor.
- Completion of all degree requirements within four years from the date of commencing coursework, normally completed in one to two years.
- Master's degree residence requirements can be met only by residence on the CU-Boulder campus for two semesters or three summer

sessions, or a combination of at least one semester and two summer sessions.

- Pass all courses with a grade of B- or better, and maintain a cumulative GPA of 3.0 or better.

Some required graduate level courses have prerequisites. Students are expected to complete prerequisite materials before enrolling in these courses. For any course (including thesis, independent study, and projects) to be counted toward the MS degree requirements, the student must earn a grade of **B- or higher**.

Students in the five-year BS/MS program must also meet the above requirements.

The specific implementation of these requirements and additional requirements for the MS degree in the Department of Aerospace Engineering Sciences are described in the focus area curricula section that begins on page 19.

Up to 9 credits from an incomplete MS program may be accepted for degree requirements; however, work already applied toward a graduate degree received from CU-Boulder or another institution cannot be accepted for transfer toward another graduate degree at the same level at CU-Boulder. For example, work already applied to meet requirements for a master's degree earned by a student cannot be used toward a second master's degree from CU. In addition, work completed for a doctoral degree may not be applied toward a subsequent master's degree. Extension work completed at another institution cannot be transferred; and correspondence work, except to make up deficiencies, is not recognized.

Up to 9 Credits from the ACCESS and CAETE programs will be accepted toward the MS degree. These credits do not have to be transferred, as they appear on the CU transcript. However, Continuing Education (non-degree) credits have to be transferred.

Guidelines for MS thesis:

The MS thesis must consist of original and independent research conducted by the graduate student under the supervision of the faculty advisor. The thesis topic must be related to the major field. The thesis must:

1. Represent the equivalent of 6 semester hours of course work.

2. Comply in mechanical features with the University of Colorado Graduate School Thesis and Dissertation Specifications.

3. Be filed with the Graduate School by posted deadlines for the semester for which the degree is to be conferred.

The examination committee for the MS thesis will consist of three graduate faculty members.

See the Graduate School Rules, http://www.colorado.edu/GraduateSchool/policies/downloads/GSRules_REV.pdf, for additional information.

Courses Satisfying Math Requirement:

Math

ASEN 5227: Aerospace Math
ASEN 5417: Numerical Methods for Differential Equations
APPM 5000, 6000, 7000 level courses
MATH 5000, 6000, 7000 level courses
ECEN 5612: Noise and Random Processes
ECEN 5632: Theory and Application of Digital Filtering
ECEN 5642: Modern Methods of Spectral Estimation
ECEN 5652: Detection and Extraction of Signals from Noise

Master of Engineering Degree

Students may elect to enroll in a Master of Engineering (ME) degree plan rather than a Master of Science, typically for one of the following reasons:

- CAETE students who are interested in a coursework only program.
- A student desires a more flexible and customized degree program (e.g. incorporating business courses) and/or does not wish to follow a specific focus area curriculum.

Requirements:

- A total of 30 credit hours, apportioned in the following way: at least 24 credits must be completed at the 5000 level or above; and at least 15 credits must be in ASEN at the 5000 level or above (seminar credit hours can not be applied toward the ME course requirements).
- Completion of all degree requirements within six years of the date of commencing course work.
- Master's degree residence requirements can be met only by residence on the CU-Boulder campus for two semesters or three summer sessions, or a combination of at least one semester and two summer sessions.
- Pass all courses with a grade of **B- or higher** and maintain a cumulative GPA of at least 3.0.

If a student is admitted on a provisional basis, a GPA of 3.25 must be maintained for each semester until 12 credit hours are completed, or the student will be suspended. Provisional students are required to take a minimum of 12 hours of graduate course work over a period of 4 semesters. Additional conditions may be placed on a provisional student at the discretion of the department, to account for individual circumstances.

Doctoral Degree

Prior to admission to the Ph.D. program, the student must have a graduate advisor (member of the Graduate Faculty) who has agreed to supervise the student's dissertation research. A student entering the Ph.D. program in Aerospace Engineering Sciences is not required to possess an MS degree; however, the student must have the proficiency required of a holder of the MS degree given in the Department of Aerospace Engineering Sciences at the University of Colorado to pass the preliminary examination (taken no later than the third semester of study). The comprehensive examination should be taken within the first 5 semesters. Once passed, the student is admitted to candidacy and officially becomes a Ph.D. candidate. Until the comprehensive examination is passed, the student is considered a doctoral student.

Program Requirements

- Total of 36 course credits numbered 5000 or above with 12 of these taken at the 6000 level or above, and at least 18 credits must be in ASEN. Up to 3 credit hours from ASEN seminars can be applied.
- Two graduate (or approved) math courses (6 credits) in ASEN, APPM or MATH.
- Up to 21 credits from an outside MS program can be applied, but not MS thesis credits. All credits earned from a MS program taken at the University of Colorado can be applied toward a Ph.D., except for master's thesis credit.
- Students are required to complete 30 dissertation credits. (See Graduate School Rules for additional information.)
- Students must pass a departmental preliminary examination, or its equivalent, by no later than the end of the 3rd semester.
- Students must pass a comprehensive examination by no later than the end of the 5th semester.
- Students must complete a Ph.D. dissertation and successfully defend the dissertation in a final examination.
- All degree requirements must be satisfied in a period of 6 years from the commencement of course work for the Ph.D.
- Course curriculum is defined by the chosen focus area and approved by the faculty advisor. See, focus area curricula charts beginning on page 19.
- The minimum residence requirement for a Ph.D. is six semesters beyond the attainment of an acceptable bachelor's degree (2 semesters from another institution may be counted towards this requirement).

- Continuous registration. A student must register for a minimum of five dissertation hours in the fall and spring semesters of each year, beginning with the semester following the passing of the comprehensive exam and extending through the semester in which the dissertation is successfully defended (final examination).
- For the Ph.D., a course mark **below B- is unsatisfactory** and will not be counted toward fulfilling the minimum requirements for the degree.
- A student who fails to maintain a 3.00 grade point average or to make adequate progress toward completing a degree, as assessed by the student's advisor, will be subject to suspension from the Graduate School upon consultation with the major department. The final decision on suspension will be made by the dean of the Graduate School.

Teaching Practicum

All Ph.D. students are expected to gain teaching experience through a Teaching Practicum. The teaching practicum reflects one year of documented teaching experience for each Ph.D. student. It may be fulfilled in a number of ways to allow flexibility to the student and their advisor based on interests, skills, and departmental needs. While some teaching activities might be paid assignments from the department (for example, a teaching assistantship or hourly course assistantship), there is no requirement for the teaching practicum to be a paid appointment.

Examples of 1 semester teaching practicum activities:

- Teaching assistant (50% appointment)
- Course assistant (20 hr/week hourly appointment)
- Team-teaching a course with advisor
- Instructor of record or GPTI
- Mentor responsible for UROP, Discovery Learning Apprentice, SURE or SMART student or high school student, for full summer or semester
- Coordinator for focus area seminar

Each student must complete the equivalent of 2 semesters of teaching activity. The advisor is responsible for specifying the teaching activities required and providing guidance and assistance to the student in this work. For teaching as a research mentor the advisor should set clear expectations for the role of the graduate student mentor and ensure that both the graduate mentor and the undergraduate student(s) they are working with understand the responsibilities and roles of each. Students should complete the teaching practicum tracking sheet available in the graduate advising office prior to or in the semester of their final defense.

Ph.D. Program Timeline and Examinations

YEAR 1 – Preparation for the Preliminary Exam
During the first year of the Ph.D. program students will take coursework needed for academic preparation, begin conducting research with their advisor, and possibly initiate their teaching practicum.

Preliminary Exam – By no later than the end of their third semester, Ph.D. students must complete the Preliminary Exam. It will normally be administered in Oct/Nov. This exam evaluates the student's qualification for the Ph.D. program. The topical coverage includes the Focus Area Core MS courses and undergraduate prerequisites for these subjects. The exam questions may require depth of understanding of individual subjects as well as the synthesis or integration of material across disciplines. The overall exam requires that students demonstrate satisfactory progress in academic preparation, research and teaching. The exam will be administered by a committee of three faculty members, two from the student's major Focus Area and one from the student's selected second Focus Area (approval of a committee member outside the student's focus area may be requested by petition to the Graduate Curriculum Committee Chair). Each faculty member provides one question for the written exam. The exam will include a written and an oral element, as determined, prepared and evaluated by the exam committee. The committee will provide an overall recommendation on the student's progress, and determine one of the following outcomes:

- Pass without modification to the student's plan of study
- Pass subject to additional courses and/or background literature review
- Fail with option to retake the exam once in the next semester

YEAR 2 – Preparation for the Comprehensive Exam and Admission to Candidacy

After completing the requisite course work a doctoral student is eligible to apply for candidacy for the Ph.D. degree by submitting the form "Application for Admission to Candidacy for an Advanced Degree" to the Graduate School. Before admission into candidacy, the student must pass a comprehensive examination. An "Exam Request Form" must be submitted to the Graduate School at least two weeks in advance of the exam.

In the second year of the program, Ph.D. students who have successfully passed the Preliminary Exam work on advancing their specialized technical expertise and in collaboration with their advisor, and they begin the process of defining their specific doctoral research topic. By no later than their fifth semester, they must select a thesis committee of at least 5 members comprising 2-3 faculty members from their primary Focus Area, 1-2 from a second Focus Area (approval of a committee member outside the student's

focus area may be requested by petition to the Graduate Curriculum Committee Chair), and 1-2 outside the department, and pass the comprehensive examination. The members of this committee must be approved by the Graduate School. This committee will serve as the examining board for the Comprehensive Examination and Final Examination.

The Comprehensive Exam tests mastery of a broad field of knowledge, not merely formal course work. It will include a written and an oral element, which together test the student's depth of understanding of their technical area. The written element will consist of a research proposal that demonstrates the student's capacity for scholarly work in their chosen topic, including a timeline for the proposed tasks. The oral exam will include a presentation by the student defending their written proposal and addressing questions from the thesis committee and other faculty who may attend. The outcome of the Comprehensive Exam is determined by Graduate School procedures. Students who successfully pass this exam then are considered Ph.D. Candidates. A successful candidate must receive the affirmative votes of a majority of the members of the examining board. The student is automatically dismissed by the Graduate School after a second failure. Details on the Comprehensive Examination format can be found on the Graduate School web site.

Successful completion of the comprehensive examination is required before a student is admitted into Ph.D. candidacy. The following guidelines for the comprehensive examination are given:

1. A student shall have earned at least four semesters of residence, have a GPA of 3.25 for all graduate ASEN or CU coursework, and shall have passed the Comprehensive Examination before admission to candidacy is approved by the Graduate School. The Comprehensive Examination must be taken at least one semester before the Final Exam.

2. The Exam is conducted by a group of at least 5 graduate faculty who comprise the thesis committee.

3. At least one week before the Exam, the candidate must provide each member of the thesis committee with a written document consisting of a detailed written proposal for the thesis research.

4. The Examination typically requires a time period of about 2 hours. The candidate makes an oral presentation on the research proposal, typically of duration of about 40 minutes. The remainder of the Exam consists of questions directed to the candidate by the committee members. The questions typically

pertain to the subject matter and content of the proposal, but may also be asked on topics outside this area, at the committee's discretion.

5. A successful candidate must receive the affirmative votes of a majority of the members of the examining board. In case of failure, the examination may be attempted once more after a period of time determined by the thesis committee. The student is automatically suspended after a second failure.

A successful written research proposal and examination convinces the thesis committee that the candidate has:

- a thorough understanding of the research literature in the chosen field
- articulated an original and significant research program
- familiarity with the tools and methods of the proposed research
- identified a project that is of the appropriate scope for a Ph.D. thesis
- a reasonable plan to complete the research in the time period allowed for the Ph.D. requirements.

Typically, a successful candidate will have conducted some preliminary research on the thesis topic prior to the examination, and these preliminary results should be included in the research proposal.

Exam forms can be obtained from the Graduate Advisor.

YEARS 3 and beyond – Dissertation Research, Professional Training, & Teaching

In the subsequent years of the program, the Ph.D. candidate will work with the faculty to conduct research which includes writing and presenting technical papers at conferences and in journals, reviewing technical papers, writing research proposals, and mentoring undergraduate, MS, or new doctoral students. They will also take advanced coursework and complete their teaching practicum. Both the advisor and student are responsible for ensuring that the work is adequately progressing. The student will meet with each of the members of their thesis committee at least once per semester to assess progress and to obtain feedback.

Ph.D. Dissertation

A dissertation based upon original investigation and showing mature scholarship and critical judgment, as well as familiarity with the tools and methods of the research, must be written upon a subject approved by the student's committee chair. Each dissertation presented in partial fulfillment of the doctoral degree must:

1. Comply in mechanical features with the University of Colorado Graduate School Thesis and Dissertation Specifications.

2. Be filed with the Graduate School by the posted deadline for the semester in which the degree is to be conferred.

Final Examination

After the dissertation has been accepted by the student's committee a final examination of the dissertation and related topics will be conducted. The following rules must be observed:

1. A student must be registered as a regular degree student on the Boulder Campus for a minimum of five, and no more than ten, dissertation hours the semester in which the final examination is scheduled.

2. The examination will be oral and open to anyone who wishes to attend

3. The examination will be conducted by the thesis committee

4. More than one dissenting vote will disqualify the candidate. In case of failure, the examination may be attempted only one more time. A second failure will result in automatic suspension by the Graduate School. Signatures from all committee members are required.

5. Arrangements for the final examination must be made in the Graduate School at least two weeks in advance of the scheduled date of the examination (this is arranged through the ASEN Graduate Advisor).

See the Graduate School Rules for additional information, http://www.colorado.edu/GraduateSchool/policies/downloads/GSRules_REV.pdf.

Focus Areas

The MS and Ph.D. programs in Aerospace Engineering Sciences are organized into five focus areas listed below. Graduate students are admitted into a specific focus area which provides research advising and financial support, and sets specialized admission and program requirements and recommendations for course work within and outside the department.

- Astrodynamics and Satellite Navigation Systems (ASN)
- Remote Sensing, Earth and Space Science (RSS)
- Vehicle Systems, including Aerodynamics, Systems and Control (VS)
- Bioastronautics (Bio)
- Structural and Material Systems (SMS)

Many of our faculty members have interests in two or more of these areas, and, in fact, some students may end up doing research that spans multiple focus areas. The purpose of defining these areas is to allow for specialization of the academic program in a sustainable way, aligned with primary research interests of the faculty. Furthermore, by bringing students directly into one of these groups we seek to facilitate and strengthen their connection with a primary advisor and with other like-minded students in the department.

Each focus area will define the required characteristics of their successful graduates at the MS and Ph.D. level and will define a set of required and elective courses to be offered on a regular basis that support their educational program. Each focus area is encouraged to look for synergy with other areas and other departments to avoid duplication and to enhance multidisciplinary education.

Focus Area Curricula Charts

The following pages provide charts listing the courses offered by each of the focus areas and their area specific requirements for the MS and Ph.D. Courses shown in bold are **MS Core** courses. All others are considered MS or Ph.D. electives.

After the 5 basic curriculum pages are additional recommendations from the focus areas.

These abbreviations are used for the focus areas:
VS - vehicle systems
Bio - bioastronautics
RSS - remote sensing, earth and space sciences
ASN - astrodynamics and satellite navigation
SMS - structures and material systems

STRUCTURAL AND MATERIAL SYSTEMS

SMS Specific MS Requirements
2 SMS Core Classes
2 of the SMS 6000 level electives

Undergraduate coursework in structural mechanics, rigid body dynamics, vibrations, and materials

SMS Specific Ph.D. Requirements

Admission to the Ph.D. program requires an MS in engineering, mathematics or physical sciences. Acceptance directly into the Ph.D. program requires clear evidence of exceptional ability as determined from GPA (above 3.8), extensive experience or publication in peer reviewed journals or conference proceedings.

Required Courses in Focus Area:

Course Number	Title	Offering (F - Fall, S – Spring, A – annually, B – biennially)
5012	Mechanics of Aerospace Structures	F, A
5022	Introduction into Dynamics of Aerospace Structures	S, A
ASEN 6xxx	Structures & Materials Seminar (required: once)	F&S, A
ASEN 7xxx	Structures & Materials Seminar (required: once)	F&S, A

Required Courses outside Focus Area:

Course Number (current)	Title	Offering (F - Fall, S – Spring, A – annually, B – biennially)
ASEN5014	Linear Control Systems	F, A

Elective Courses offered by Focus Area:

Course Number (current)	Title	Offering (F - Fall, S – Spring, A – annually, B – biennially)
5007	Introduction into Finite Elements	F, A
5107	Nonlinear Finite Elements	S, B
6337	Advanced Finite Elements for Plates & Shells	S, B
5218	Structural System Design	S, B
5519	Design Optimization of Aerospace Systems	S, B
6XXX	Experimental Structural Mechanics (not offered yet)	F, B
6XXX	Coupled Problems of Aerospace Systems	F, B

Courses currently 5000-level which should automatically count as 6000-level courses until course number has officially changed:

Course Number Current	Course Number New
5519 – Design Opt.	*6???*

Core Faculty:

Carlos Felippa
Mahmoud Hussein
Jean Koster
Kurt Maute
K.C. Park
Lee Peterson

VEHICLE SYSTEMS (FLUID DYNAMICS, SYSTEMS AND CONTROL) (VS)

VS Specific MS Requirements
2 VS Core Classes in one technical area (Fluid Dynamics or Systems and Control)

VS Specific Ph.D. Requirements
2 of the VS 6000 level electives in one technical area

Admission to the Ph.D. program requires an MS in engineering, mathematics or physical sciences. Acceptance directly into the Ph.D. program requires clear evidence of exceptional ability as determined from GPA (above 3.8), extensive experience or publication in peer reviewed journals or conference proceedings.

Technical Area: Systems and Control
Core Courses in Focus Area:

Course Number (current)	Title	Offering (F - Fall, S – Spring, A – annually, B – biennially)
ASEN 5114	Automatic Control Systems	F
ASEN 5014	Linear Systems Theory	F
ASEN 5148	Spacecraft Design	S ?

Core Courses outside Focus Area:

Course Number (current)	Title	Offering (F - Fall, S – Spring, A – annually, B – biennially)
ASEN 5010	Attitude Dynamics and Control	

Elective Courses offered by Focus Area:

Course	Title	Offering (F - Fall,

Number (current)		S – Spring, A – annually, B – biennially)
ASEN 5024	Nonlinear Systems	B, S
ASEN 5519	Cooperative Control of Multi-Vehicle Systems	B, S
ASEN 6xxx	System Identification for Control	B, S
ASEN 5519	UAS Design	Special Topic – Guest Lecturer
ASEN 6xxx	VS Seminar (GHB)	A
ASEN 7xxx	VS Seminar (GHB)	A

Technical Area: Fluids

Core Courses in Technical Area:

Course Number (current)	Title	Offering (F - Fall, S – Spring, A – annually, B – biennially)
ASEN 5051	Intro to Fluid Mechanics	F
ASEN 5327	Computational Fluid Dynamics	F

Elective Courses offered by Focus Area:

Course Number (current)	Title	Offering (F - Fall, S – Spring, A – annually, B – biennially)
ASEN 5427	Computational Gas Dynamics	B
ASEN 6xxx	Microfluidics	B
ASEN 6xxx	Advanced CFD	B
ASEN 5xxx	Stability and Turbulence	B,S
ASEN 5053	Rocket Propulsion	F
ASEN 5063	Gas Turbine Propulsion	F
ASEN 6xxx	Molecular Gas Dynamics and Direct Monte Carlo Simulation	B
ASEN 6xxx	Viscous Flow	B
ASEN 6xxx	VS Seminar (GHB)	A
ASEN 7xxx	VS Seminar (GHB)	A

Courses currently 5000-level which should automatically count as 6000-level courses until course number has officially changed:

Course Number Current	Course Number New	Application Status (a – approved, p – pending, n – nothing done yet)	Faculty in charge
ASEN 5024	ASEN 6024	n	Lawrence
ASEN 5519	Cooperative Control of Multi-Vehicle Systems	n	Frew
ASEN 6xxx	System Identification for Control	n	Lawrence

Core Faculty:

Brian Argrow
Sedat Biringen
Eric Frew
Dale Lawrence
Kamran Mohseni
Scott Palo
Ryan Starkey

BIOASTRONAUTICS

Bio Specific MS Requirements
ASEN 5016
ASEN 5158 *or* 5116
ASEN 5335-Aerospace Env (RSS)

Bio Specific PhD Requirements

This specialized field of study addressing human spaceflight is typically augmented with coursework tailored to meet the student's specific career interests, and may include related topics in spacecraft engineering design, life sciences or other areas relevant to the needs of the research.

ASEN 5016
ASEN 5158 *or* 5116
ASEN 5506 Bioastronautics Seminar (presentation)

Required Courses in Focus Area:

Course Number (current)	Title	Offering (F - Fall, S – Spring, A – annually, B – biennially)
ASEN 5016	Space Life Sciences	S
ASEN 5116	Spacecraft Life Support Systems	F (B)
-- OR --		
ASEN 5158	Space Habitat Design	F (B)

Required Courses outside Focus Area:

Course Number (current)	Title	Offering (F - Fall, S – Spring, A – annually, B – biennially)
ASEN 5335	Aerospace Environment	A?

Elective Courses offered by Focus Area:

Course Number (current)	Title	Offering (F - Fall, S – Spring, A – annually, B – biennially)
ASEN 5506	Bioastronautics Seminar	S (*A, but not in 2008*)
ASEN 5849	Independent Study (for MS Project)	on request
ASEN 6849	Independent Study (for PhD 'pre/non-thesis' topic)	on request

Courses currently 5000-level which should automatically count as 6000-level courses until course number has officially changed*:*

Course Number Current	Course Number New	Application Status (a – approved, p – pending, n – nothing done yet)	Faculty in charge
ASEN 5016		*N*	*Klaus*
ASEN 5116		*N*	*Klaus*
ASEN 5158		*N*	*Klaus*

Core Faculty:

David Klaus
Virginia Ferguson (Mechanical Engineering)
Kevin Gifford
Louis Stodieck

ASTRODYNAMICS AND SATELLITE NAVIGATION SYSTEMS (ASN)

ASN Specific MS Requirements
3 ASN Core Classes
ASEN 5335-Aerospace Env (RSS) *or* ASEN 5148-Spacecraft Design (VS)

Required Courses in Focus Area:

Course Number (current)	Title (faculty who teach)	Offering (F - Fall, S – Spring, A – annually, B – biennially)
ASEN 5010	Attitude Dynamics and Control (Schaub)	S, A
ASEN 5050	Space Flight Dynamics (Nerem)	F, A
ASEN 5090	Introduction to GNSS (Axelrad, Larson, Akos)	F, A
ASEN 5070	Statistical Orbit Determination (Born)	F, A

Required Courses outside Focus Area:

Course Number (current)	Title	Offering (F - Fall, S – Spring, A – annually, B – biennially)
ASEN 5335	Aerospace Environment (Forbes)	F,A
ASEN 5148	Spacecraft Design (McGrath)	S,A

Elective Courses offered by Focus Area:

Course Number (current)	Title	Offering (F - Fall, S – Spring, A – annually, B – biennially)
ASEN 6070	Satellite Geodesy (Nerem)	F/B
ASEN 6080	Statistical Orbit Determination 2 (Born)	S/B
ASEN 6519	Astro Applications of Dynamical Systems Theory	F/B
ASEN 6519	Interplanetary Mission Design (Born)	?/B
	Trajectory Optimization (Scheeres)	?/B
ASEN 6090	Advanced GNSS Software (Larson)	S/B
ASEN 6519	Satellite Navigation Receiver Architecture (Akos)	S/B
ASEN 6xxx	ASN Seminar	FS/A
ASEN 7xxx	ASN Seminar (Presenter)	FS/A

Courses currently 5000-level which should automatically count as 6000-level courses until course number has officially changed:

Course Number Current	Course Number New	Application Status (a – approved, p – pending, n – nothing done yet)	Faculty in charge
5060	*6070*	*approved*	*Nerem*
5080	*6080*	*Stat OD 2*	*Born*

Core Faculty:

Dennis Akos
Penny Axelrad
George Born
Robert Culp
Kristine Larson
Steve Nerem
Scott Palo
Hanspeter Schaub

REMOTE SENSING, EARTH and SPACE SCIENCE (RSS)

Remote Sensing, Earth and Space Sciences focus area is a field that embodies a broad multidisciplinary approach. The expected competency at the graduating masters level in the RSS focus area is to have completed course work 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 or Vehicle Systems. The expected competency at the PhD level is to further advance the four primary topics within RSS by complementary theory and analysis obtained through course work offered at the 6000 level and above, and by research activities in developing the PhD thesis.

Required courses needed to specialize in the RSS focus area are:

One course in data or numerical analysis (1)
One course in instrumentation (2)
One course in physical science (3)
One course in astrodynamics or vehicle systems (4)
And the Remote Sensing Seminar, 1-credit course

Below is a list of core RSS courses, offered regularly by the AES faculty, that satisfy the four primary topics. These are listed as core courses as their content satisfies a primary topic in our focus area. Students can design a course schedule with their graduate faculty advisor to insure their course selections satisfy the RSS focus area. It is possible to petition courses outside of these core courses to fulfill the required course work as long as they meet the four topics of study outlined above and that the general guidelines of the AES graduate program are met.

Core Courses in Focus Area:

Course Number (current)	Title (RSS topic of study) (1) Data or Numerical Analysis Methods, (2) Instrumentation Fundamentals, (3) Physical Sciences of Earth and Space, and (4) Astrodynamics or Vehicle Systems	Offering (F - Fall, S – Spring, A – annually, B – biennially)
ASEN 5168	Remote Sensing Instrumentation (2)	S-A
ASEN 5215	Oceanography (3)	S-A
ASEN 5245	Radar and Remote Sensing (2)	S-A
ASEN 5307	Engineering Data Analysis (1)	S-A
ASEN 5335	Aerospace Environment (3)	F-A
ASEN 5337	Remote Sensing Data Analysis (1)	F-A
ASEN 5519	Fundamentals of Optical remote Sensing: Spectroscopy (2)	F-A
ASEN	Microcontroller Fundamentals with Aero	F-A

5519	Applications (2)	
ASEN 5519 ASEN 6519	[1]Spaceflight Hardware I (2) Spaceflight Hardware II (2)	S-A, F-A (two semester course)
ASEN 6210	Remote Sensing Seminar (required)	S-A

Note: [1]This two-semester course can also be used to satisfy the AES graduate program requirement for 6 credits of project work

Core Courses outside Focus Area (only if particular course required):

Course Number (current)	Title (RSS topic of study) (1) Data or Numerical Analysis Methods, (2) Instrumentation Fundamentals, (3) Physical Sciences of Earth and Space, and (4) Astrodynamics or Vehicle Systems	Offering (F - Fall, S – Spring, A – annually, B – biennially)
ASEN 5014	Linear Systems Theory (4)	F-A
ASEN 5050	Space Flight Dynamics (4)	F-A
ASEN 5051	Fluid Mechanics (3 or 4)	F-A
ASEN 5061	Intro to Real Gas Dynamics (3 or 4)	F-A
ASEN 5070	Statistical Orbit Determination 1 (4)	F-A
ASEN 5090	Global Navigation Satellite Systems (2 or 4)	F-A
ASEN 5148	Spacecraft Design (4)	S-A

Elective Courses in Focus Area:

Course Number (current)	Title (RSS topic of study) (1) Data or Numerical Analysis Methods, (2) Instrumentation Fundamentals, (3) Physical Sciences of Earth and Space, and (4) Astrodynamics or Vehicle Systems	Offering (F - Fall, S – Spring, A – annually, B – biennially)
ASEN 6519	Special Topics in Aerospace Environment: Upper Atmospheres (3)	S-B
ASEN 6519	Laser Remote Sensing: Fundamentals and Applications in Science and Engineering (2)	S-B

Elective Courses offered outside of Focus Area:

Course Number (current)	Title(RSS topic of study) (1) Data or Numerical Analysis Methods, (2) Remote Sensing Instrumentation Fundamentals, (3) Physical Sciences of Earth and Space, and (4) Astrodynamics or Vehicle Systems	Offering (F - Fall, S – Spring, A – annually, B – biennially)
ASEN 5227	Aerospace Math (1or 4)	F-A

ASEN 5327	Computational Fluid Mechanics (1,3 or 4)	S-A
ASEN 5417	Numerical Methods for Differential Equations (1 or 4)	S-A
ASEN 5519	Ocean Modeling (3)	F-B
ASEN 6060	Satellite Geodesy (4)	S-B
ASEN 6080	Statistical Orbit Determination (4)	S-B
ATOC 5050	Introduction to Atmospheric Dynamics (3)	F-A
ATOC 5060	Dynamics of the Atmosphere (3)	S-A
ATOC 5051	Introduction to Physical Oceanography (3)	F-A
ATOC 5235	Introduction to Atmospheric Radiation Transfer and Remote Sensing (2)	S-A
ASTR 5140	Astrophysical and Space Plasmas (same as Phys 5141) (3)	F-A
ASTR 5150	Introduction to Plasma Physics (same as Phys 5150) (3)	S-A
ASTR 5300	Introduction to Magnetospheres (3)	F-B
APPM 5520	Introduction to Mathematical Statistics (1)	S-A
APPM 5570	Statistical Methods (1)	F-A
APPM 5350	Methods in Applied Mathematics: Fourier Series and Boundary Value Problems (1)	S-A
APPM 5540	Introduction to Time Series (1)	S-A
APPM 5580	Statistical Methods for Data Analysis (1)	S-A
ECEN 5134	Electromagnetic Radiation and Antennas (2)	F-A
ECEN 5254	Radar Remote Sensing (2)	S-B
ECEN 5612	Noise and Random Processes (1)	F-A
ECEN 5632	Theory and Application of Digital Filtering (1)	F-A
ECEN	Modern Methods of Spectral Estimation (1)	S-A

5642		
ECEN 5652	Detection and Extraction of Signals from Noise (1)	S-A
PHYS 7310	Electromagnetic Theory I	F-A

Core Faculty:

Xinzhao Chu	Scott Palo
Bill Emery	Jeff Thayer
Jeff Forbes	Kristine Larson
Lakshmi Kantha	Xinlin Li

Certificates

The University of Colorado recognizes that interdisciplinary study at the graduate level may involve coursework and formal requirements that exceed those of established degree programs. To recognize this additional work by graduate students, interdisciplinary faculty may establish a certificate program within the Graduate School. In addition to earning a Certificate while pursuing a graduate degree, the Graduate School has extended the Certificate program to students who have received a B.A. or B.S. degree and are continuing to take courses but are not enrolled in a graduate degree program and meet the course prerequisites.

Students in the Department of Aerospace Engineering Sciences may want to consider obtaining a Certificate in Atmospheric and Oceanic Sciences, or a Certificate in Remote Sensing.

Certificate in Atmospheric and Oceanic Sciences

The Program in Atmospheric and Oceanic Sciences (PAOS) is an interdisciplinary program at the University of Colorado that provides an educational and research environment to study the dynamical, physical and chemical processes of the atmosphere and the ocean.

Requirements for a Graduate Certificate in Atmospheric and Oceanic Sciences:

1. Approval by the ASEN Certificate Chairman of your proposed course selection.

2. Completion, with a grade of B or better, of a total of four courses from the approved list of PAOS/ASEN courses.

3. Upon completion of your courses, submission of a letter to the ASEN Graduate Program Advisor requesting a Certificate in Atmospheric and Oceanic Sciences, for consideration by the ASEN Certificate Chair.

List of PAOS courses suitable for ASEN students:

ASEN 5215: Oceanography

ASEN 5235/ATOC 5235: Introduction to atmospheric radiative transfer

ASEN 5315: Ocean Modeling

ASEN 5325: Small-scale Processes in the Atmosphere and Ocean

ASEN 5335: Aerospace Environment

ASEN 6519: Turbulence in Atmospheric Boundary Layer

ATOC 5051: Introduction to Physical Oceanography

ATOC 5060: Dynamics of the Atmosphere

ATOC 5061: Dynamics of Oceans

ATOC 5600: Physics and Chemistry of Clouds and Aerosols

ATOC 5810: Planetary Atmospheres

ATOC 6100: Predicting Weather and Climate

CHEM 5151: Atmospheric Chemistry

GEOG 5231: Physical Climatology: Field Methods

ASEN 5900: Directed Studies in Atmospheric Science

Letters to the Atmospheric and Oceanic Sciences Graduate Committee should be sent to the Atmospheric and Oceanic Sciences Graduate Chair:

Professor Bill Emery
431 UCB
(303) 492-8591
william.emery@colorado.edu

Certificate in Remote Sensing

Remote sensing (satellite and ground-based) is increasingly being used as a technique to probe the Earth's 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 the students' regular degree program. An additional purpose is to encourage multi-disciplinary education of the students in the area of remote sensing.

Graduate students, research staff, and faculty work on a wide variety of topics, ranging from the theory of remote sensing, to its application. These applications include: use of satellite remote sensing to determine ocean surface temperature and heat fluxes; use of surface radar to improve the determination of clouds and precipitation from satellite; determination of surface biological characteristics and productivity from satellite; mapping of land use from satellite; mapping of surface landform and topographical features; searching for locations of buried artifacts; use of surface radar to determine upper atmosphere wind motions; and aircraft remote sensing to assess the validity of satellite retrieval algorithms of surface and atmospheric characteristics.

A Certificate in Remote Sensing will be awarded based on a written request by the student to the Remote Sensing Graduate Chairman, provided that the following requirements have been met:

All students must take at least three Remote Sensing courses from the list below (passed with grade B or better) and complete at least one semester of the Remote Sensing Seminar, ATOC 7500/ASEN 6310. This class is offered once each year. Most remote sensing courses are offered once each year.

The Remote Sensing graduate courses are:

ATOC 7500/ASEN 6310: Remote Sensing Seminar (*required)

ASEN/ATOC 5235: Radiative Transfer of the Earth’s Atmosphere

ASEN 5337: Remote Sensing Data Analysis

ASEN 5168: Remote Sensing Instrumentation

ASEN 5245/ECEN 5254: Radar and Remote Sensing

ASEN 6220: Directed Studies in Remote Sensing

ECEN 5274: Radar Science and Techniques

GEOL/GEOG 5093: Remote Sensing of the Environment

GEOL5440/GEOG 6443-2: Remote Sensing Field Methods

GEOL 6340: Remote Sensing of Planetary Surfaces

Letters to the Remote Sensing Graduate Committee should be sent to the Remote Sensing Graduate Chair:

Professor Bill Emery
431 UCB
(303) 492-8591
william.emery@colorado.edu

Contact Persons

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Appendix A - Tentative Course Offerings (for planning purposes only)

Focus Area: Structural and Material Systems

Fall 07

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
5007	Introduction into Finite Elements	y(?)	Felippa	none
5012	Mechanics of Aerospace Structures	y	Park	None

Spring 08

Course Number Current	*Title*	*Required (y/n)*	*Instructor*	*Pre-Req.*
5022	Intro. into Dynamics of Aerospace Structures	Y	Park	5012
6xxx	New course - TBD	N	Hussein	

Fall 08

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
5007	Introduction into Finite Elements	Y(?)	Felippa	None
5012	Mechanics of Aerospace Structures	Y	Park	None
6(7)xxx	Seminar	Y	Hussein	None

Spring 09

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
5022	Intro. Dynamics of Aerospace Systems	Y	Park	None
6xxx	Design Optimization of Aerospace Systems	N	Maute	5012, 5007
6xxx	Space System Design	N	Peterson	
6(7)xxx	Seminar	Y	Hussein	None

Focus Area: Vehicle Systems (Fluid Dynamics, Systems And Control)

Technical Area: Systems and Control

Fall 07

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
ASEN 5114	Automatic Control Systems	Y	Frew	none
ASEN 5014	Linear Systems Theory	Y	Lawrence	none
ASEN 5519	UAS Design	N	Lee (visitor)	none

Spring 08

Course Number Current	*Title*	*Required (y/n)*	*Instructor*	*Pre-Req.*
ASEN 6xxx	System Identification for Control	N	Lawrence	ASEN 5014 or ASEN 5114 or equiv.

Fall 08

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
ASEN 5114	Automatic Control Systems	Y	Frew	none
ASEN 5014	Linear Systems Theory	Y	Lawrence	none

Spring 09

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
ASEN 5024	Nonlinear Systems	n	Lawrence	ASEN 5014
	And/or			
ASEN 5519	Cooperative Control of Multi-Vehicle Systems	n	Frew	ASEN 5014 or ASEN 5114 or equiv.

Technical Area: Fluids*Fall 07*

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
ASEN 5051	Intro to Fluids	Y	Mohseni	none
ASEN 5053	Rocket Propulsion	N	Kantha	???
ASEN 5063	Gas Turbine Propulsion	N	Kantha	???
ASEN 5227	Aerospace Math	N	Argrow	Undergradute Calc III, Diff Eq.

Spring 08

Course Number Current	*Title*	*Required (y/n)*	*Instructor*	*Pre-Req.*
ASEN 6xxx	Microfluidics	N	Mohseni	???
ASEN 5327	Computational Fluid Dynamics	Y	Biringen	???
ASEN 5xxx	Stability and Turbulence	N	Biringen	???

Fall 08

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
ASEN 5051	Intro to Fluids	Y	?	none

Spring 09

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
ASEN 5327	Computational Fluid Dynamics	Y	?	none

Courses currently 5000-level which should automatically count as 6000-level courses until course number has officially changed:

Course Number Current	Course Number New	Application Status (a – approved, p – pending, n – nothing done yet)	Faculty in charge
ASEN 5024	ASEN 6024	n	Lawrence
ASEN 5519	Cooperative Control of Multi-Vehicle Systems	n	Frew
ASEN 6xxx	System Identification for Control	n	Lawrence

Focus Area: Bioastronautics

Fall 07

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
ASEN 5158	*Space Habitat Design*	*Y (or 5116)*	*Klaus*	*N/A*

Spring 08

Course Number Current	*Title*	*Required (y/n)*	*Instructor*	*Pre-Req.*
ASEN 5016	*Space Life Sciences*	*Y*	*Klaus*	*N/A*

Fall 08

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
ASEN 5116	*Spacecraft Life Support Systems*	*Y (or 5158)*	*Klaus*	*N/A*

Spring 09

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
ASEN 5016	*Space Life Sciences*	*Y*	*Klaus*	*N/A*
ASEN 5506	*Bioastronautics Seminar*	*N*	*Klaus*	*N/A*

Focus Area: Astrodynamics and Satellite Navigation

Fall 07

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
ASEN 5050	Space Flight Dynamics	*Y*	*Nerem*	*none*
ASEN 5090	Introduction to GNSS	*Y*	*Axelrad*	*none*
ASEN 5070	Stat Orbit Determination	*Y*	*Born*	*5050*
ASEN6519	Astrodynamics Applications of Dynamical System Theory	*N*	*Born*	*5050, 5010?*

Spring 08

Course Number Current	*Title*	*Required (y/n)*	*Instructor*	*Pre-Req.*
ASEN 5010	*Spacecraft Attitude Dynamics and Control*	*Y*	*Schaub*	*none*
ASEN 6090	*Advanced GNSS Software*	*N*	*Larson*	*5090*
ASEN 6070	*Geodesy*	*N*	*Nerem*	*5050*

Fall 08

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
ASEN 5050	Space Flight Dynamics	*Y*	*Nerem*	*none*
ASEN 5090	Introduction to GNSS	*Y*	*Larson &'09*	*none*
ASEN 5070	Stat Orbit Determination	*Y*	*Born*	*5050*
ASEN 60??	*Trajectory Optimization*	*N*	*Scheeres*	*5050*

Spring 09

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
ASEN 5010	*Spacecraft Attitude Dynamics and Control*	*Y*	*Schaub*	*none*
ASEN 6519 ASEN 6091	Satellite Navigation Receiver Architectures	*N*	*Akos*	*5090*

Focus Area: Remote Sensing and Earth / Space Science

Fall 07

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
ASEN 5335	Aerospace Environment (4)	*y*	*Forbes*	
ASEN 5307	Engineering Data Analysis (2)	*y*	*Emery*	
ASEN 5519	Fundamentals of Optical remote Sensing: Spectroscopy (3)	*y*	*Chu*	
ASEN 5519	Microcontroller Fundamentals with Aero Applications (3)	*y*	*Pisano*	
ASEN 6519	Spaceflight Hardware II (2)	*y*	*Palo / Li*	*Must have taken Spring '07 section*
ASEN 5051	Fluid Mechanics (4)	*y*	*Mohseni*	
ASEN 5061	Intro to Real Gas Dynamics (3)	*y*	*Argrow*	
ASEN 5014	Linear Systems Theory (4)	*y*		
ASEN 5050	Space Flight Dynamics (4)	*y*		
ASEN 5090	Introduction to GPS (2)	*y*		
ASEN 5070	Satellite Orbit Determination 1 (4)	*y*		

Spring 08

Course Number Current	*Title*	*Required (y/n)*	*Instructor*	*Pre-Req. / Comments*
ASEN 5215	Oceanography (3)	*y*	*Emery*	
ASEN 6210	Remote Sensing Seminar (required)	*y*	*Emery*	
ASEN	Special Topics in	*y*	*Forbes /*	*ASEN 5335 or*

6619	Aerospace Environment: Upper Atmospheres (3)		*Thayer*	*instructors permission*
ASEN 5245	Radar and Remote Sensing (2)	*y*	*Thayer*	*May not be offered this semester ECEN 5254 can be used as an alternate*
ASEN 5519	Spaceflight Hardware I (2)	*y*	*Palo / Li*	*Two semester course starts in spring of each year*
ASEN 5148	Spacecraft Design (4)	*y*	*McGrath*	
ASEN 5060	Satellite Geodesy (4)	*y*		*Biennial*
ASEN 5080	Satellite Orbit Determination 2 (4)	*y*		*Biennial*

*Fall 08**

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
ASEN 5335	Aerospace Environment (4)	*y*	*Forbes*	
ASEN 5307	Engineering Data Analysis (2)	*y*	*Emery*	
ASEN 5519	Fundamentals of Optical remote Sensing: Spectroscopy (3)	*y*	*Chu*	
ASEN 5519	Microcontroller Fundamentals with Aero Applications (3)	*y*	*??*	
ASEN 6519	Spaceflight Hardware II (2)	*y*	*?? / Li*	*Two semester course starts in spring of each year*
ASEN 5051	Fluid Mechanics (4)	*y*	*Mohseni*	
ASEN	Intro to Real Gas	*y*	*Argrow*	

5061	Dynamics (3)			
ASEN 5014	Linear Systems Theory (4)	*y*		
ASEN 5050	Space Flight Dynamics (4)	*y*		
ASEN 5090	Introduction to GPS (2)	*y*		
ASEN 5070	Satellite Orbit Determination 1 (4)	*y*		

**Palo on sabbatical*

*Spring 09**

Course Number Current	Title	Required (y/n)	Instructor	Pre-Req.
ASEN 5215	Oceanography (3)	*y*	*Emery*	
ASEN 6210	Remote Sensing Seminar (required)	*y*	*Emery*	
ASEN 6619	Special Topics in Aerospace Environment: Upper Atmospheres (3)	*y*	*Forbes / Thayer*	*ASEN 5335 or instructors permission*
ASEN 5245	Radar and Remote Sensing (2)	*y*	*Thayer*	
ASEN 5519	Spaceflight Hardware (2)	*y*	*?? / Li*	*Two semester course starts in spring of each year*
ASEN 5148	Spacecraft Design (4)	*y*	*McGrath*	
ASEN 5060	Satellite Geodesy (4)	*y*		*Biennial*
ASEN 5080	Satellite Orbit Determination 2 (4)	*y*		*Biennial*
ASEN 6619	Laser Remote Sensing: Fundamentals and Applications in Science and Engineering (2)	*y*	*Chu*	

*Palo on sabbatical