ASEN 3128 Aircraft Dynamics

Syllabus

Lecture:	AERO 120	M, W	2:30 – 3:45 pm
Lab:	AERO 141	F	8:30 – 10:20 am, 1:30 – 3:20 pm

Instructors

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Text

Required: *Dynamics of Flight: Stability and Control*, Bernard Etkin and Lloyd Reid, John Wiley and Sons. 3rd Ed., 1996

Prerequisites

ASEN 2002, 2003, 2004, and APPM 2360 (min grade C).

Overview

This course covers the key ideas that enable an understanding of how aircraft work and tools for quantitative analysis and design methods to achieve specified dynamical behavior. Because aircraft exist in many different forms, and new designs continue to be developed, the focus is on the common principles that underlie atmospheric flight, so that a solid basis can be formed for future work in most any direction. Concrete treatment of these ideas, tools, and methods is provided through working problems in assigned groups, consisting of analysis, simulation, and design problems, including development of MATLAB simulation models for two very different vehicles: a quad-copter and a conventional airplane.

In their full expression, aircraft dynamics possess astounding complexity, and it is a tribute to the ideas developed by aviation's pioneers that a relatively simple understanding can often be obtained, leading to clear insights and design principles. While these concepts are not inherently

difficult, they do lie outside most common experience, and they depend on new nomenclature and strange notation that can seem overwhelming at first. It is only through diligent and careful use of this new language that the underlying simplicity can be grasped and conveyed on exams; mastery of the language of aircraft dynamics is perhaps the most important predictor for success in the course.

The course has been designed to develop a conceptual grasp of the key ideas below, and to demonstrate proficiency in using these concepts to solve problems, construct and validate simulations, and to explain behaviors and results obtained. In particular, engineering reasoning skills using these concepts are stressed in assignment solutions and examinations. The key learning objectives are:

Vector mechanics

- Vector representation in coordinate frames
- Change of coordinate frame representation (coordinate rotation)
- Relative motion, frame derivatives
- Change of derivative frame: velocity rule

How aircraft dynamics models are created and what the terms mean

- 3D rigid body translational model
    - Kinematics
    - Dynamics, external forces
    - Effects of wind
- 3D rigid body rotational model
    - Kinematics, Euler angle attitude representation
    - Dynamics, Euler moment equations, external moments
- External forces and moments
    - Aerodynamic effects
    - Control effects
    - Steady flight conditions, trim states

How aircraft dynamics models are simulated

- State space models
- Matlab integration
- Good naming and commenting habits

How dynamical behavior is understood and specified

- Linearization
- Decoupling
- Stability derivatives
- Modal solutions
- Stability characterizations
- Modal specifications

How feedback control is designed to meet behavioral objectives

- Sensor selection, control structure
- Effects on mode eigenvalues

Course Components

Material and concepts are introduced, and student mastery is evaluated using several mechanisms throughout the course:

Reading – The textbook provides the essential basis for the course, including the concepts, terminology, notation, methods, and examples used to convey the course topics. Specific reading assignments will be given covering key sections of the book; some book sections are not covered in the course. Some supplementary material will also be provided.

Lectures – These are intended to emphasize key ideas and methods that make the material easier to grasp. They are therefore a counterpart to the reading, not a replacement. The value of lectures is dependent on your participation in them. Passive "watching" will provide little benefit. Active note taking is critical to developing first-hand familiarity with the notation, terminology, and methods, and to gaining comfort in using them. Although lectures will be recorded, this is a poor substitute for your own lecture notes. Questions are encouraged during lectures, and will be prompted often. Professor Lawrence will lecture primarily for the first half of the course, and Professor Ahmed will lecture primarily for the second half.

Assignments – These provide first-hand experience employing the reading and lecture material. They consist of analysis and computation exercises, simulation development, and simulation use to address aircraft stability and control design problems. Assignments will be carried out in small groups. Although assignments will be graded individually, group collaboration in their preparation is encouraged through a peer evaluation process that rates group work contributions and has a strong effect on an individual's group work grade in the course. Please see the **Assignment_Format** and **Peer_Eval_Grading** documents for details. Students are expected to use these assignments and the associated group learning opportunities to strengthen their **individual** mastery of the subject. Dividing up the learning on assignments by dividing up the work is a recipe for failure on the individual exams in this course.

Proper presentation of engineering work is important throughout the ASEN curriculum, as in professional life thereafter, and students are expected to properly describe what was done and explain results using graphical and written descriptions based on the precise terminology and notation introduced in the course.

A secondary objective of the Assignments is the development of proficiency with numerical simulation, and to develop good programming habits. Simulation is becoming an indispensable tool in engineering, and proficiency is expected of professionals in this field.

Exams – These are the primary means of evaluation of your individual grasp of the course material. Three in-class written exams will be conducted at approximately five-week intervals. Exams will include both conceptual questions and quantitative problems. Precise use of terminology and notation is stressed. The final exam is comprehensive in that it will contain material from the entire course, but emphasis will be placed on the final third of the course material.

Logistics

1. Office hours for Instructors and TAs will be held nominally during the arranged "lab" times for the course, in the Pilot Laboratory (AERO 141). This is intended to provide ease-of-access to instructor and TA help, primarily during group work on the weekly assignments, but any questions about course material are welcome. To help avoid congestion, students assigned to a lab section have priority for that section. However, instructors and TAs are available to all students during these "lab" times. This mode of "supervised learning" can be quite efficient, particularly if groups are prepared by attempting the assignments ahead of time, and come to the "lab" sessions with questions. The assignments are handed out the week before the intended "lab" time in order to enable this "first-pass" in advance. Additional office hours with instructors and TAs can also be scheduled. Private meetings with instructors or TAs can also be arranged if needed.

2. Attendance at all lectures and lab sessions is essential. In-class discussion of assignments or important announcements may be given at any time. Students who come to class prepared and participate in discussions typically have a more rewarding experience. Attendance at "lab" sessions is equally important. The instructors and TAs will be present for all lab sessions, and the individual assistance this affords can be extremely valuable. Also, notebooks will be "graded" during lab sessions (see below), and your participation in the group (or lack thereof) will show in the peer evaluations that strongly affect your group work grade in the course.

3. Taking your own notes: first hand contact with the notation and diagrams is key to understanding the material in this course, and to conveying your understanding on exams. Lectures will be recorded for repeated viewing, to ensure details are not missed. But there is no substitute for taking your own notes. To encourage due diligence here, notebooks will be reviewed on a random basis by the TAs during the lab sessions, and quality of notetaking will contribute to your individual work grade in the course (see the Grading section below).

4. Collaboration is required on Assignments with the assigned group. Group membership will be rotated several times during the semester. Collaboration outside the assigned groups is also encouraged, provided it is used to assist your individual learning, rather than substitute for it. Discussing the means and methods for solving problems, comparing answers, etc. can be valuable to you, but blindly copying is not. Grading in the course is designed to evaluate **individual** understanding, and this is only developed through personal experience with the material. Moreover, the peer evaluations of group work are designed to fairly evaluate group contributions, and group grades will **strongly** depend on member contributions.

5. Quizzes will be given weekly in an on-line format. These will cover the reading material, lectures, and portions of the weekly Assignments. Quiz grades will contribute to your individual course grade, and are designed to encourage you to come to class and lab prepared.

4. Examinations- Midterm exams will be given during lecture periods. The final exam is scheduled according to University policy. Exams are the primary means of assessing individual proficiency and in determining grades in the course. Assignments are group-oriented and designed to develop proficiency in order to do well individually on exams. Accordingly, group work cannot substitute for individual assessments. See the grading policy below. Any type of collaboration or copying on an exam constitutes a breach of professional ethics and will result in an F for the course. An honor code violation or accusation report will also be filed. **There will be a statute of limitations on when exam grades can be corrected:** all requests for corrections must be made in writing before the next exam, detailing the specific part(s) to be addressed together with specific justification. Regrading discussions will be limited to these concerns.

6. Deadlines – Deadlines must be enforced to ensure fairness and to enable timely grading. Late assignments are subject to a 20% penalty per day. (E.g. 0-24 hours late = 1 day penalty) except under extenuating circumstances such as a school closure or serious illness. If such an illness occurs you are expected to contact the instructor immediately by email, before the due date. No other accommodations will be provided, e.g. a hectic schedule or crashed computer will not be considered. Please plan for these contingencies by including some margin in your schedule. If you know in advance that you will not be on campus for a due date, you may submit your assignment to the instructor any time prior to the due date.

Grading

Grading Philosophy

Assignments and exams are graded to an absolute standard designed to indicate your level of competency in the course material. The final grade indicates your readiness to continue to the next level in the curriculum. The AES faculty have set these standards based on our education, experience, interactions with industry, government laboratories, others in academe, and according to the criteria established by the ABET accreditation board.

The course grade is primarily dependent on **individual** measures of competency, i.e. exams. The other course assignments are designed to enrich the learning experience and to enhance individual performance, not to substitute for sub-standard individual competency. Accordingly, group assignment grades are only incorporated into the final grade when the individual grade is a C or better. **In other words, if your individual average is below a C, the group-based grade fraction will not be averaged into your final grade, which will then be based solely on your exam/quiz scores and notebook grade.** This policy makes it important to use the group assignments to enhance *your own* learning. Although it may seem more efficient to split up the assignment among group members, this is dangerous because the learning is also split up, and this often results in poor performance on exams, and significant risk of repeating the course. Recommended practice is to work the assignments first on your own, then use the group interactions and instructor/TA help to answer questions and refine and deepen your understanding.

Grades for the course are set based on the following criteria:

A, A-	Demonstrates mastery of the course material in both conceptual and quantitative aspects.
B+, B	Demonstrates comprehensive understanding of the material, with a solid conceptual grasp of key concepts and strong quantitative work.
B-, C+	Demonstrates good understanding of most key concepts, with few major quantitative errors.
C	Demonstrates adequate understanding of the material to proceed to the next level; sufficient quantitative work.
C-	Does not demonstrate adequate understanding of the material to proceed to the next level, or makes persistent quantitative errors.
D	Very little understanding is evident, consistently poor quantitative work.
F	Unsatisfactory performance.

Final letter grades are based on the numerical grades earned during the semester, roughly corresponding to the standard University grading scale. Students are cautioned that numerical grades near the critical 73% level (a nominal C) may or may not result in a C for the course.

It is recognized that all students do not have the same objectives in terms of course grades, but the risk of repeating the course and delaying graduation is great if the individual score is close to 73% going into the final exam. It is strongly recommended to avoid this situation by making use of all assistance available (e.g. group assignment participation, lecture participation, instructor/TA help) to prepare for the exams.

Grade Breakdown

Your final grade is a combination of an individual work (IW) and group work (GW) score.

Type	**Description**	**Percentage**
Individual Work (IW)	Midterm Exams (2)	50% (25% each)
	Final Exam	30%
	Quizzes	10%

	Notebook	10%
IW Score	Total Individual Score	100%
Group Work (GW)	Weekly Assignments	100%
GW Score	Total Group Score	100%

Final Course Score

Your final course score is computed as follows

- If your Individual Work (IW) grade is **below a C**, then your Final Score (FS) is the Individual Work (IW) score. In this case FS = IW.

- If your Individual Work (IW) grade is **a C or better,** then your Final Score is computed as the weighted average of the Individual Work (IW) and Group Work scores (GW). This formula is

  $$FS = 0.6*IW + 0.4*GW,$$

  subject to the limitation that averaging in your GW score does not reduce your FS. Thus the group work score can only help your final grade (often significantly).

  This is then equivalent to an overall breakdown:

Assignments	40 %
Notebook	6 %
Quizzes	6 %
2 Midterm Exams	30 %
Final Exam	18 %
	100 %

Exam Schedule

Midterm 1: Monday, September 30, 2:30-3:45 pm, AERO 120
Midterm 2: Monday, November 4, 2:30-3:45 pm, AERO 120
Final Exam: Monday, December 16, 1:30-4:00 pm, AERO 120

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Assignment Schedule

Assignments will be posted on Friday and due before the Friday two weeks later. The first week of each Assignment is designed for preliminary "first-pass" individual attempts of the problems, and the second week is designed for group finalization of the Assignment solutions and for instructor/TA help during "lab" times.

Quiz Schedule

Quizzes will be conducted on-line through Canvas. They will be open each week from Friday until 11:59 PM on Sunday. Only one attempt of each question is allowed, and Quiz answers will not be accepted after the deadline. Solutions will be posted after the deadline.

Honor Code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the academic integrity policy of the institution. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access, clicker fraud, resubmission, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code Council (honor@colorado.edu; 303-735-2273). Students who are found responsible of violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code Council as well as academic sanctions from the faculty member. Additional information regarding the academic integrity policy can be found at http://honorcode.colorado.edu.

General University Policies

Accommodation for Disabilities
If you qualify for accommodations because of a disability, please submit to your professor a letter from Disability Services in a timely manner (for exam accommodations provide your letter at least one week prior to the exam) so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities. Contact Disability Services at 303-492-8671 or by e-mail at dsinfo@colorado.edu. If you have a temporary medical condition or injury, see Temporary Injuries guidelines under the Quick Links at the Disability Services website and discuss your needs with your professor.

Religious Holidays
Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, you must let the instructors know of any such conflicts within the first two weeks of the semester so that we can work with you to make reasonable arrangements. See campus policy regarding religious observances for full details.

Class Behavior

Students and faculty each have responsibility for maintaining an appropriate learning environment, not only while in class but also while working outside of class. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, color, culture, religion, creed, politics, veteran's status, sexual orientation, gender, gender identity and gender expression, age, disability, and nationalities. Class rosters are provided to the instructor with the student's legal name. We will gladly honor your request to address you by an alternate name or gender pronoun. Please advise us of this preference early in the semester so that we may make appropriate changes to our records. For more information, see the policies on classroom behavior and the student code.

Discrimination and Harassment

The University of Colorado Boulder (CU-Boulder) is committed to maintaining a positive learning, working, and living environment. CU-Boulder will not tolerate acts of sexual misconduct, discrimination, harassment or related retaliation against or by any employee or student. CU's Sexual Misconduct Policy prohibits sexual assault, sexual exploitation, sexual harassment, intimate partner abuse (dating or domestic violence), stalking or related retaliation. CU-Boulder's Discrimination and Harassment Policy prohibits discrimination, harassment or related retaliation based on race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. Individuals who believe they have been subject to misconduct under either policy should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127. Information about the OIEC, the above referenced policies, and the campus resources available to assist individuals regarding sexual misconduct, discrimination, harassment or related retaliation can be found at the OIEC website.