ASEN 3128 AIRCRAFT DYNAMICS Spring 2023 Syllabus

LECTURE

Tuesday & Thursday	8:30 - 9:45 am	AERO 120
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Lab

Tuesday	2:45 - 4:35 pm	AERO 141
Wednesday	8:30 - 10:20 am	AERO N100
Wednesday	10:35 - 12:25 pm	AERO N100

INSTRUCTORS

Professor Morteza LahijanianOffice:AERO 267Email:Morteza.Lahijanian@colorado.edu

<u>Supplemental:</u> Small Unmanned Aircraft: Theory and Practice, Randal W. Beard and Timothy W. McLain, Princeton University Press, 2012.

<u>Supplemental</u>: Flight Stability and Automatic Control, 2nd Ed., Robert C. Nelson, MdGilaw 1998.

PREREQUISITES

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

OVERVIEW

This course covers the key ideas that enable: (i) an understanding of how aircraft work and tools for quantitative analysis, and (ii) 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 individually and 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. It is a tribute to the ideas

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
 - o State space models
 - o Matlab integration
 - o Good naming and commenting habits
- How dynamical behavior is understood and specified
 - o Linearization
 - o Decoupling
 - Stability derivatives
 - Modal solutions
 - Stability characterizations
 - o Modal specifications
- How feedback control is designed to meet behavioral objectives
 - o Sensor/feedback selection, control structure
 - Effects on mode eigenvalues

TEACHING MODALITIES

Lecture Lectures will be in person throughout the semester. All lectures will be automatically

Lab Sections Students are expected to register for one of the three lab sections and be available for interaction during the scheduled lab section. Groups for lab assignments will be made from students in the lab sections only, and groups will be periodically shuffled prior to the start of certain assignments.

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. The textbook contains a wealth of information, but the concepts and notation are new to most: some sections need to be read more than once to fully grasp the material.

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 rovide 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.

Homework Homework problems provide individual practice in solving problems of varying difficulty and sometimes will also involve computing. Collaboration on homework is allowed (<u>copying is not</u>); however, students are encouraged to use homework as a means to ensure their individual mastery of the subject. In-class group problem-solving and labs will allow for considerable collaborative learning opportunities.

Reading Quizzes These will cover the reading material, lectures, and portions of the lab assignments. Quiz grades will contribute to your individual course grade and are designed to encourage you to come to class and lab prepared. They will consist of true-false and multiple-choice-style questions similar in format to questions that will be on the exams.

Lab 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. Students are expected to use these assignments and the associated group learning opportunities to strengthen their <u>individual</u> mastery of the subject. <u>Dividing the learning on assignments by naively dividing work is a certain recipe for failure on exams in this course</u>.

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. In-class, written exams are planned for week 6 and week 13; the <u>final exam is TBD by</u> <u>the university</u>. 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 quarter of the course material.

LOGISTICS

 Office hours office hours for Instructors and TAs will be held nominally during the and AERO N100. 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, penalty) except under extenuating circumstances. If such a circumstance occurs you are expected to contact the instructor and TF immediately by email, before the due date. <u>No</u> 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 on Gradescope any time prior to the due date. <u>It is your</u> responsibility to manage assignment submissions and deadlines.

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. As with all other standards

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, inform the instructors of such conflicts at least three weeks in advance.

See the campus policy regarding religious observances for full details.

Schedule

The expected course schedule is as follows (some updates and adjustments may occur during course of the semester):

Week		
No. Dates	Tuesday	Thursday

Lab Day