AEM 668: Advanced Flight Dynamics & Control

Instructor: Dr. Jordan D. Larson

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Office Hours: 3:00-5:00pm Tue Thu (and by appointment)

Prerequisites: None

Credit Hours: 3

Course Description:

The objective of this is to teach advanced concepts related to flight dynamics and control including fixed-wing, rotary-wing, orbital, and projectile aerospace vehicles. This course will provide high fidelity nonlinear modeling for aerospace vehicle dynamics including vibrations, variable mass, unsteady atmosphere, variable gravity, rotating and ellipsoidal Earth, and model uncertainties. Multiple input, multiple output feedback control system design for aerospace vehicles will be developed focusing on linear optimal control theory.

Student Learning Outcomes:

At the successful conclusion of this course, a student will have gained the ability to:

1. model and analyze high fidelity nonlinear aerospace vehicle dynamics;
2. simulate a variety of aerospace vehicle dynamics with automatic feedback control;
3. analyze and simulate additional elastic body degrees-of-freedom for aerospace vehicles;
4. model and analyze the effects of uncertainties in aerospace vehicles; and
5. design and synthesize multiple input, multiple output optimal control laws for aerospace vehicles.

Course Textbook:

The course textbook PDF is provided for free from Dr. Jordan D. Larson.

Required Software:

The latest version of MATLAB/Simulink with the Control Systems Toolbox is necessary for completion of the coursework. MATLAB can be downloaded for free by students at

https://techwiki.eng.ua.edu/index.php/Category:Software

Other Course Materials:

(Optional) Curtis, H. D., *Orbital Mechanics for Engineering Students*, 1st ed., Vol. 1, Butterworth-Heinemann, Oxford, 2013

(Optional) Lavretsky, E., and Wise, K. A., *Robust and Adaptive Control: With Aerospace Applications*, 2nd ed., Vol. 1, Springer, New York, 2024

(Optional) Nelson, R. C., *Flight Stability and Automatic Control*, 2nd ed., Vol 1., McGraw-Hill, New York, 1997

(Optional) Schmidt, D. K., *Modern Flight Dynamics*, 1st ed., Vol. 1, McGraw-Hill, New York, 2012

(Optional) Sidi, M. J., *Spacecraft Dynamics and Control: A Practical Engineering Approach*, 1st ed., Vol. 1, Cambridge University Press, Cambridge, 2000

(Optional) Stevens, B. L., Lewis, F. L., and Johnson, E. N., *Aircraft Control and Simulation: Dynamics, Controls Design, and Autonomous Systems*, 3rd ed., Vol. 1, Wiley-Blackwell, New York, 2015

Outline of Topics:

Module 1: Introductory Aerospace Vehicle Dynamics & Classical Control
Module 2: Advanced Rigid Aerospace Vehicle Dynamics
Module 3: Elastic Aerospace Vehicle Dynamics
Module 4: Modern LTI Feedback Control Theory
Module 5: Optimal Control Theory and Design

Exams and Coursework:

Due Date	Due Time	Assignment	Percent of Grade
Sep. 30	11:59 PM	Project 1	$16.\bar{6}\%$
Oct. 21	11:59 PM	Project 2	$16.\bar{6}\%$
Nov. 4	11:59 PM	Project 3	$16.\bar{6}\%$
Nov. 18	11:59 PM	Project 4	$16.\bar{6}\%$
Dec. 9	11:59 PM	Project 5	$16.\bar{6}\%$
Dec. 10	10:00 AM	(Take-Home) Final Exam	$16.\bar{6}\%$

Information and Rules:

1. Programming must be completed in MATLAB/Simulink.
   - All MATLAB command window outputs and plots must be generated as specified.
   - All Simulink models must be submitted.
   - MATLAB code must follow the provided MATLAB code style for the course.
2. Must be worked and submitted individually.
   - Collaboration while working through the homework is highly encouraged.
3. Must be submitted online through Blackboard *before* the date and time indicated above.
   - Late submissions are accepted at 50% credit up to two days past the due date and time indicated above.
4. Students have seven days from the completion of grading a homework to review and dispute the score.

There are *no* extra credit opportunities for this course.

Grading Policy:

Standard **Graduate Grading Ranges**

Letter Grade	Percentage Range
A	90-100%
B	80-89.9%
C	70-79.9%
D	60-69.9%
F	0-59.9%

1. Grading ranges *may be* expanded or shifted only to the *benefit* of the student at the *end* of the semester.
2. If this happens, then all students will be treated consistently.
3. Students should not count on expanded or shifted grading ranges.

Policy on Missed Exams and Coursework:

Late projects are *only* accepted up to **two days after** the date and time indicated above for 50% credit. After two days, no credit will be given. Missed exams are **not accepted**.

Extensions on projects and exams are **not given unless**: **before** the due date, there is a **documented excuse** provided to the instructor regarding one of the following events:

1. sickness which disables the student from attending class or poses a significant threat to the health of others;
2. sickness of, or accident involving, a spouse or dependent, which requires the student to be with the spouse or dependent;
3. an accident which necessarily prevents the student's attendance in class;
4. the death of a family member or close friend;

5. interview for a summer internship or for a permanent position after graduation, if the interview cannot reasonably be scheduled to avoid conflict; or
6. a meeting or event at which the student must appear as a representative of the University of Alabama.

Attendance Policy:

Final grades are *not* affected by absences.

Elasticity Statement:

The instructor will make every effort to follow the guidelines of this syllabus as listed; however, the instructor reserves the right to amend this document as the need arises. In such instances, the instructor will notify students in class and/or via email and will endeavor to provide reasonable time for students to adjust to any changes.

Statement on Academic Misconduct:

https://catalog.ua.edu/undergraduate/about/academic-regulations/student-expectations/code-academic-conduct/

Statement on Disability Accommodations:

https://catalog.ua.edu/undergraduate/about/support-programs/disability-services/

Severe Weather Protocol:

https://ready.ua.edu/severe-weather-guidelines/

Pregnant Student Accommodations

Title IX protects against discrimination related to pregnancy or parental status. If you are pregnant and will need accommodations for this class, please review the University's FAQs at https://www.ua.edu/campuslife/uact/information/pregnancy

Religious Observances

Under the Guidelines for Religious Holiday Observances, students should notify the instructor in writing or via email during the first two weeks of the semester of their intention to be absent from class for religious observance. The instructor will work to provide reasonable opportunity to complete academic responsibilities as long as that does not interfere with the academic integrity of the course. See full guidelines at https://provost.ua.edu/oaa-guidelines-for-religious-holidays-observance.

UAct Statement

The UAct website provides an overview of The University's expectations regarding respect and civility at

https://www.ua.edu/campuslife/uact/