

Mechanical Engineering 547

Flight Dynamics and Control of Aircraft

<u>Instructor:</u>	Dr. David S. Rubenstein
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<u>Class Hours:</u>	Tuesdays, Thursdays, 11:00AM – 12:15PM
<u>Location:</u>	Remote via Adobe Connect Pro
<u>Office Hours:</u>	Through email and Adobe Connect meetings (Students can log on as if it were a class session) through special arrangement.
<u>Prerequisites:</u>	MEE 445 or by permission of instructor
<u>Text:</u>	<i>Dynamics of Flight: Stability and Control</i> , Third Edition, B. Etkin, and L.D. Reid.
<u>Technical software:</u>	MATLAB Student Version (includes Matlab and Simulink).

Course description

This course provides an introduction to the flight dynamics, modeling and fundamental stability and control aspects of aircraft. The course covers aircraft roll, pitch and yaw static stability and control basics and develops the full nonlinear equations of motion. The concept of numerical simulation of these equations is also introduced. Finally, with the dynamic models in-hand, open-loop response to actuation of the control systems is analyzed and the concept of closed-loop aircraft control system design is presented.

Educational Objectives: After completing this course, students will be able to:

- I. calculate and analyze aircraft trim and static stability characteristics;
- II. analyze dynamic aircraft flight conditions using the non-linear state equations;
- III. assess aircraft stability from the linearized equations of motion;
- IV. compute and demonstrate understanding of aircraft lateral and longitudinal modes and effects;
- V. demonstrate basic understanding of aircraft open-loop control response;
- VI. demonstrate basic understanding of aircraft closed-loop control design concepts and approaches.

Topics

I. Fundamental Review of Aeronautics

- *Aircraft Reference Frames, Notation and Terminology*
- *Primary Definitions, Aerodynamic Angles, Forces and Torques*
- *Static Stability Basics*

II. Static Stability and Control

- *Longitudinal Dynamics and Control*
- *Elevator and Control Force Effects*
- *Trim Tabs*
- *Propulsion Effects*
- *Lateral Dynamics and Coupling*
- *Yaw and Roll Control*

III. Aircraft Equations of Motion (EOM)

- *Aircraft Position and Orientation*
- *Stability-Frame and Body-Frame*
- *Euler's Equations*
- *Small Disturbance Theory and Linearization of EOM*
- *Stability and Control Derivatives*

- *Numerical Solutions and Flight Simulation*

IV. Dynamic Stability and Open-Loop Response to Actuation

- *Response using Linearized Models and State Space*
- *Longitudinal and Lateral modes, Mode Approximations*
- *Disturbance Effects*
- *Elevator and Throttle Responses*
- *Aileron and Rudder Responses*

V. Introduction to Closed-Loop Control Response

- *Stability and Control Augmentation Basics*
- *Basic Concepts of an Aircraft Autopilot*
- *Pitch Attitude Control*
- *Speed Control*
- *Altitude and Glide Control*

VI. Additional Topics

- *Modern Control Techniques*
- *Introduction to Aircraft Navigation – Instruments, GPS and Integration Filters*

Additional References

1. Shevell, Richard S., *Fundamentals of Flight, Second Edition*, Pearson Prentice-Hall, Upper Saddle River, NJ, 1989.
2. McCormick, Barnes W., *Aerodynamics, Aeronautics and Flight Mechanics, Second Edition*, John Wiley and Sons, Inc., Canada, 1995.
3. Stevens, B. L. and Lewis, F. L., *Aircraft Control and Simulation, Second Edition*, John Wiley and Sons, Inc., Hoboken, New Jersey, 2003.

Class Time

Students are expected to attend the live lecture sessions and review lectures via the recordings.

Homework

- Homework problems will be assigned approximately every one to two weeks. You are expected to do the homework assignments individually. The homework problems are the basis for the preliminary and final exams. You are responsible for submitting the assigned homework if you are absent from the class.
- Late homework will NOT be accepted.
- Please be very neat and clear on homework. Clearly define variables, vectors, reference frames, etc. Nomenclature and convention can be pretty much as you please but you MUST be clear and consistent.

Preliminary Examinations

There will be two preliminary examinations.

Simulation Project

A simulation project will be assigned mid to late semester.

Final Exam

A comprehensive final exam will cover all material up to and including the last lecture before the exam.

Grading

Homework	5%
Preliminary Exam #1	20%
Preliminary Exam #2	20%
Simulation Design Project	30%
Final Exam	25%

Disabilities (ADA) Statement

Students with disabilities who may need services or accommodations to fully participate in this class should contact Ann Smith, Director of Disability Services in 121 East Annex, (voice) 581-2319, (TTY) 581-2325 as early as possible in the semester. Any student requiring an accommodation due to a disability is also encouraged to speak to the instructor privately at the beginning of the semester. Appropriate arrangements will be made to accommodate the student.

Academic Integrity

Academic dishonesty includes cheating, plagiarism and all forms of misrepresentation in academic work, and is unacceptable at The University of Maine. As indicated in the University of Maine's on-line "Student Handbook," plagiarism (the submission of another's work without appropriate attribution) and cheating are violations of The University of Maine Student Conduct Code. An instructor who has probable cause or reason to believe a student has cheated may act upon such evidence, and should report the case to the supervising faculty member or the Department Chair for appropriate action.

Class Disruption:

In the event of an extended disruption of normal classroom activities, the format for this course may be modified to enable its completion within its programmed time frame. In that event, you will be provided an addendum to the syllabus that will supersede this version.