SYLLABUS

# AME 459 – Flight Mechanics
# Department of Aerospace and Mechanical Engineering

Fall Semester, 2020

Instructor: Kamal Shweyk
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| **Course Sections:** | 28829R |
| **Course Unit:** | 3 Units |
| **Prerequisite:** | Undergraduate Senior Level Standing |
| **Class Hours:** | Thursdays, 4:00-6:50 PM (includes a break midway) |
| **Class Location:** | Virtual |
| **Office Hours:** | Fridays, 4:00-7:00 PM |
| **Teaching Assistant:** | Ashwin Sivakumar |

## Course Background

This class will address the aerodynamics, performance, propulsion, stability and control, and flight controls of atmospheric flight vehicles. The class assumes a basic understanding of fluid dynamics, and will cover in details the derivation of the equations of motion, aircraft static and dynamic stability, aircraft response to control inputs and atmospheric disturbances, flight simulation, and the fundamentals of classical, feedback, control theory.

The instructor will apply his extensive work experience in the aerospace industry to illustrate, through real-life examples, the application of theory to practice.

## Course Components

Students' learning experience in this course will come from three (3) interrelated components:

- **Textbook Reading**

  The class will use the textbook, "Introduction to Aircraft Flight Mechanics", by Thomas R. Yechout, 2nd Edition. The class will follow the basic structure of the text book starting with a brief overview/refresher of the first three chapters on Basic Aerodynamics, Basic Performance, and Aircraft Performance. The class will begin in depth starting with Chapter 4, where the Aircraft Equations of Motion will be explained and derived, and conclude with Chapter 8, where an introduction to the Classical Feedback Control will be offered. Additional class modules, beyond the scope of the text book, will be included to discuss special topics related to Flight Mechanics, such as Atmospheric Disturbances, Wake Turbulence, System Failure States, and Motion-Base Simulators.

- **Online Lecture**

  The online lectures, mandated due to COVID-19, will discuss theories, methodologies, processes, tools, and practice used in the aerospace industry to understand and analyze atmospheric flight vehicles, and will include current news within the aerospace industry. The focus is on fixed-wing, atmospheric, flight vehicles. The lectures will generally follow the chapter sequence of the textbook. However, the lectures will also contain significant other material, drawn from many reference books, technical papers, and industry standards, as well as the instructor's own extensive experience in the industry. The intent is to cover other important topics that are related to Flight Mechanics, including atmospheric disturbances, wake turbulence, aircraft system failures, and both ground and flight simulators. Lecture notes will be made available before class via the USC Blackboard.

- **Supplementary Reading**

  Additional reading assignments from various references will be given throughout the semester. All students are encouraged to prepare for the lectures by reading the assigned chapter and other suggested material.

## Office Hours

Due to COVID-19, office hours will be virtual. The students may email the instructor ahead of time to make the necessary arrangements. Students may also contact the TA for questions and help at any time.

## Required Textbook

- "*Introduction to Aircraft Flight Mechanics*", Second Edition, by Thomas R. Yechout, the AIAA Education Series, Second Edition, Copyright 2014.

Additional Reference Material: (The instructor will be recommending other reading material and website references during the course.)

- "*Dynamics of Atmospheric Flight*", by Bernard Etkin, John Wiley & Sons, Inc.
- *"Flight Stability and Automatic Control"*, ($2^{nd}$ edition), by Robert C. Nelson, The McGraw-Hill Companies, Inc.

## Course Website

The students' learning of this course is supplemented by use of the UCS Blackboard instruction system (https://blackboard.usc.edu/). All registered students have access to this website. The course website structure will be implemented to support the specific organization of the course instruction, as described in this syllabus. All students should browse the entire site to familiarize themselves with various areas and functions of this course website.

- Announcements – Important announcements of this course.
- Syllabus – Contains an up-to-date copy of the class syllabus.
- Assignments – Each homework and reading assignment will be posted.
- Content – A pdf copy of the lecture slides.
- Discussions – A place for the students to share their thoughts about class-related subjects.
- Groups – All communication tools, including emails and roster.
- Websites – links to reference material.

## Course Grading

The course grading structure, which is described in more details below, is as follows.

- 30% – Homework
- 20% – Quizzes
- 20% – Mid-Term Exam
- 30% – Final Exam

## Grading Components

- **Homework (30%)**

  Homework assignments will be issued on a weekly basis, with the exception of exam weeks. Students are expected to submit homework on time. Late homework will not be accepted without a valid and credible excuse.

- **Quizzes (20%)**

  A short quiz will be administered on two occasions during the semester to test the students understanding of covered lecture material and work assignments. In total, these quizzes will constitute 15% of the semester grade.

- **Mid-Term Exam (20%) and Final Exam (30%)**

  Both the Mid-Term and Final-Term exams will adopt the same format, and will include a Closed-Book section and an Open-Book section. The Closed-Book section is designed to test the student's comprehension of fundamental concepts, and will be limited to materials already covered in the classroom lectures. The answers are typically brief and illustrate basic understanding of key principles. The Open-Book section is designed to test the student's understanding and application of methods, formulas, and data from the text book and/or lectures notes. Make-up exams will not be offered, unless there is a compelling and an unavoidable circumstance, such as an urgent health matter.

## Academic Integrity

The Viterbi School of Engineering adheres to the University's policies and procedures governing academic integrity as described in SCampus. Students are expected to be aware of, and to strictly observe, the academic integrity standards described in SCampus, and to expect those standards to be enforced in this course without exception.

## Students with Disabilities:

Any Student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP and handed to the instructor as early in the semester as possible. DSP office may be reached at 213-740-0776.

***The Instructor reserves the right to change this schedule and topics during the semester.***

| Class # | Date | Class Topic | Chapter # | Remarks |
|---|---|---|---|---|
| 1 | 20 Aug 20 | Introduction to Air Vehicle Stability and Flight Controls, Brief History of Flight, Overview of Class Content. | - | |
| 2 | 27 Aug 20 | Review of Basic Aerodynamics/Fluid Dynamics, Propulsion, and Aircraft Performance; Airspeeds. | 1, 2, 3 | |
| 3 | 03 Sep 20 | Aircraft Performance; Takeoff/Landing, Endurance/Range. Equations of Motion; Axis Systems, Forces and Moments. | 3, 4 | |
| 4 | 10 Sep 20 | Aircraft Static Stability; Longitudinal Static Stability, Stability Derivatives, Neutral Stability, Static Margin. | 5 | |
| 5 | 17 Sep 20 | Aircraft Static Stability; Lateral-Directional Static Stability, Side Force, Rolling Moment, Yawing Moment. | 5 | Quiz #1 |
| 6 | 24 Sep 20 | Aircraft Static Stability; Roll and Yaw Control Power. Linearized Equations of Motion; Small Perturbation Theory. | 5, 6 | |
| 7 | 01 Oct 20 | Special Topics; Inertial Coupling, Stability Criteria, Wake Vortices, Nose Vortices, Winglets, Wing Rock, Stall, Spin. | | |
| 8 | 08 Oct 20 | Aircraft Dynamic Stability; Spring-Mass-Damper System, Laplace Transformation. | 7 | Mid Term Exam |
| 9 | 15 Oct 20 | Aircraft Dynamic Stability; Transfer Functions, $1^{st}$ and $2^{nd}$ Order Systems, Complex Plane Roots, Aircraft Modes. | 7 | |
| 10 | 22 Oct 20 | Aircraft Dynamic Stability; Response System Types, Flying Qualities and Design Criteria. | 7 | |
| 11 | 29 Oct 20 | Special Topics; Atmospheric Disturbances, Turbulence Models and Effects, Gust Sensitivity. | | Quiz #2 |
| 12 | 05 Nov 20 | Special Topics; Ground/Flight Simulators, Aeroelasticity, Classical Feedback Control; Transfer Functions | 8 | |
| 13 | 12 Nov 20 | Classical Feedback Control; Closed-Loop Control, Freq Response, Bode Plots, Stability Augmentation, Autopilots. | 8 | |
| 14 | 19 Nov 20 | **Final Exam.** | | Final Exam |