SYLLABUS

AME 532a: Flight Vehicle Stability & Control

Spring Semester, 2020
(Updated 2020-01-02)

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Course Sections:	28896R and 29066D
Course Unit:	3 Units
Prerequisite:	AME 459, Flight Mechanics or equivalent is recommended preparation. AME 451, Linear Controls or equivalent is recommended preparation. (Or with a special approval by the Instructor)
Class Hours:	Thursday, 6:40 pm to 9:20 pm
Class Location:	USC Olin Hall (OHE 100B)
Office Hours:	Thursdays, 5:00-6:30pm – BY APPOINTMENT ONLY – call or email – Meet in coffee shop or other location – Can meet virtually via phone/internet I will try to be available every Thursday 5:00-6:30, but no guarantees
Teaching Assistant:	N/A

Course Background:
This course will cover the applications of control system design to aircraft and missiles. The class assumes a basic understanding of fluid dynamics, along with a significant understanding of flight vehicle performance and dynamics. The class will cover the development of fully non-linear 6 degree of freedom simulators, linearization of the equations of motion, and the application of classical and state space control design to contemporary aircraft designs. The class will employ Matlab/Simulink (including the Control System Toolbox) to problems of inner loop control augmentation, outer loop designs, and autonomous flight.

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

- **Textbook Reading**

  The class will use the textbook, ― Aircraft Control and Simulation, Third Edition, by Brian L. Stevens and Frank L. Lewis. The class will focus on the later parts of the book which covers control system and autopilot design. The earlier parts of the book covering conventions, dynamics, aerodynamics, performance, and basic flight mechanics will be briefly reviewed to ensure all students understand this background material. The majority of the class will focus on chapters 4, 5 and 6 plus additional supplemental material.

- **Classroom Lecture**

  Lectures will discuss the relevant theories, methodologies, processes, tools, and practice used in the aerospace industry to understand and analyze aerospace vehicle flight control. The lectures will cover Stevens and Lewis chapters 1-6 and will bring in additional material (i.e., PowerPoint slides), drawn from many reference books and technical papers.

- **Supplementary Reading and Projects**

  Additional reading assignments from various reference resources will be given throughout the semester as additional required reading. All students are encouraged to prepare for the lectures by reading the assigned chapter and any additional required reading prior to the lecture. There will be one project assigned which consists of an autopilot design and verification.

Office Hours:

Office hours are by appointment only, before or after class. Make an appointment by phone or email.

Required Textbook:

- *Aircraft Control and Simulation, Third Edition*, by Brian L. Stevens and Frank L. Lewis, John Wiley & Sons, Inc.

Recommended Reference Books:

- *Introduction to Aircraft Flight Mechanics*, Second Edition, by Thomas R. Yechout, the AIAA Education Series, Copyright 2014
- *Flight Stability and Automatic Control*, (2nd edition), by Robert C. Nelson, The McGraw-Hill Companies, Inc.
- *Automatic Control of Aircraft and Missiles*‖ (3rd edition), by John H. Blakelock, John Wiley & Sons, Inc.
- *Optimal Control and Estimation*, by Robert F. Stengel, Dover Books on Mathematics
- *Linear System Theory and Design*, by Chi-Tsong Chen, Oxford University Press

The instructor may recommend additional reading materials and website reference resources during the semester whenever appropriate.

Course Website:

Students' learning of this course is supplemented by use of the USC DEN Desire 2 Learn instruction system (http://den.usc.edu/). All registered students have access to this website and should go to AME532. The course website structure is implemented to support the specific organization of the course instruction as described in this syllabus. All students should browse around 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 along with dates for quizzes and exams.

- Content – pdf copies of selected lecture material.
- Discussions – a place for the students to share their thoughts about interesting subjects with the class
- Groups -- all communication tools, including emails and roster.
- Websites – links to reference material.

Course Grading:
Students will be graded according to the following scheme:

- 10% -- Classroom/Lecture Participation
- 25% -- Homework
- 25% -- Project/Presentation
- 20% -- Mid-Term Exam
- 20% -- Final Exam

Each of the above grading components is described in more details below.

Grading Components:

- **Classroom/Lecture Participation (10%)**

  The intent is for AME532 to be an involved class. Class participation is more than just counting the attendance (which is also important). The students are encouraged to ask questions, to complete reading assignments and to participate in discussions. This can be done during class, on-line, or via the homeworks and projects.

- **Homework (25%)**

  Homework assignments will be posted on a regular basis. Students are expected to submit homework on time. Late homework will not be accepted unless there is a valid and credible excuse.

- **Project (25%)**

  A project will be assigned early in the semester. The project objective will be to build a 6 degree of freedom simulator and visualization with student designed autopilot in the loop. The project will be presented/demonstrated to the class during the final meeting of the semester, and a brief report on the project will be written and submitted.

- **Mid-Term (20%) and Final (20%) Examinations**

  Both the mid-term and the final will follow the same format.
    - Part of the exam may be **closed book**—testing for understanding of fundamental concepts. This portion will be limited to the materials that have been discussed in classroom lectures. Answers will require an essay response but should be made brief and point specific. They often require only short answers that show your comprehension of the concepts, definitions, and approaches.
    - Part of the exam may be **open book**—for problem solutions where fundamental formula and data from the text may be required.

Make-up exams will only be offered when there is proven need by the student. Should you have to miss your exams, an individual makeup exam will be scheduled with the instructor.

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 observe the academic integrity standards described in SCampus, and to expect those standards to be enforced in this course."

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. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m. - 5:00 p.m., Monday through Friday. The phone number for DSP is (213)740-0776.

Course Schedule (subject to change):

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

Week No	Date	Class Subject	Text Chapter	Comments
1	1/10	Course objectives. Course expectations. Nomenclature. Conventions. Coordinate systems. Conversions.	1	Project Assigned
2	1/17	Earth. Rotations. Quaternions. Time Varying Coordinate Systems.	1	HW 01 due
3	1/24	Translational Kinematics. Rotational Kinematics. Translational Dynamics. Free Body Simulation in Simulink Example..	1, 2	HW 02 due
4	1/31	Rotational Dynamics. Demo of Free Body Simulation with Visualization.	1, 2	HW 03 due
5	2/7	Rotating internal components. State Equations. Non-Linear State Space Model. Intro to Linearization.	1, 2, 5	HW 04 due Project Progress Update 1 due
6	2/14	Forces and moments from static aerodynamic surfaces and fuselages.	2, 3	HW 05 due
7	2/21	Forces and moments from moving aerodynamic surfaces and propellers.	2, 3	HW 06 due
8	2/28	**Midterm Exam - First 1 hour** **Second part of class – Props. Motors. Batteries.**	2, 3	
9	3/7	Propulsion Modelling. Simulation/Integration Methods.	2, 3	
10	3/14	**NO CLASS—SPRING BREAK**		
11	3/21	Longitudinal Static Stability Analysis. General Dynamic Stability Analysis. Trim/Linearize for Local Analysis. State Space Representation.	2, 4, 5	HW 07 due Project Progress Update 2 due
12	3/28	Interpretation of State Space Matrix. Partitioning and Modal Decomposition. Control Allocation. Actuator Models. Sensor Models.	4, 5	
13	4/4	Fast/Slow Dynamics. Transfer Functions. Role of the Autopilot. Classic Controller (PID) Design. LQR.	4, 5	
14	4/11	Simulation Example/Demo. Estimators.	5, 6	HW 08 due
15	4/18	LQE. Kalman Filters. Decoupling Controller Design. Discrete Controllers.	5 ,7	Project Reports due
16	4/25	Project Presentations	-	Project Presentations due and presented
17	5/2	**Final Exam (two hours)**		7:00 to 9:00 pm