AE 157 - Aerospace Automatic Control Systems Design, Spring 2020

Instructor Information: Professor Long Lu
Long.Lu@sjsu.edu

TAs (Graders): Stefan Blandin and Evan Foley

Credit: 3 units

Class Times & Locations: Tue and Thu 10:30 AM-11:45 AM at ENG 331

Office Hours & Locations: Tue and Thu 12:00 PM-1:00 PM and 5:00 PM-6:00 PM at ENG 164C

Prerequisites: Grades of "C-" or better in Math 129A, Math 133A, and AE 138. Or Graduate Standing.

Main Textbook: Ogata, K. *Modern Control Engineering*. Pearson.

Additional References:
[1] Dorf, R. C. and Bishop, R. H. *Modern Control Systems*. Prentice Hall.
[2] Nelson, R. C. *Flight Stability and Automatic Control*. McGraw-Hill Education.
[3] Nise, N. S. *Control Systems Engineering*. John Wiley & Sons, Inc.

Course Description:

Modeling and analysis of aerospace feedback control systems. Stability analysis, root locus design, and frequency response methods for aerospace vehicles and associated automatic control systems. Bode diagrams, gain and phase margins. Controllability and observability. Lead-lag, state-feedback control system, PID compensator, linear quadratic regulator designs for aircraft and spacecraft. State-observer design for the reconstruction of state variables.

Course Goals:
Introduce students to:

1. Mathematical modeling of dynamic systems such as aircraft and spacecraft
2. Analysis and design of aerospace automatic control systems based on classical and modern control techniques
3. Development of optimal control strategies to stabilize or improve the performance of aircraft and spacecraft

Course Learning Objectives:

Upon successful completion of this course, students should be able to:

1. Derive and obtain mathematical models of dynamic systems such as aircraft and spacecraft
2. Understand and apply fundamental concepts of classical and modern control strategies with applications to aircraft and spacecraft
3. Describe and analyze transient responses in aircraft and spacecraft
4. Analyze frequency responses of aerospace automatic control systems
5. Explain the concept of feedback and its role in the stabilization and control of aerospace vehicles
6. Define and analyze stability margins in aerospace vehicle motions
7. Determine the natural frequencies and damping ratios of aircraft and spacecraft dynamics
8. Evaluate the effect of feedback on aircraft and spacecraft system performance
9. Derive transfer functions for aircraft and spacecraft systems
10. Plot aerospace vehicle time and frequency responses
11. Design closed-loop control systems to stabilize or improve the performance of aircraft and spacecraft using classical control design techniques
12. Derive the state-space models for dynamic systems
13. Determine the state-transition matrix and use it to obtain the state response functions
14. Analyze the controllability and observability of aerospace systems
15. Design state-feedback control systems based on modern control design techniques
16. Design optimal control systems such as the linear quadratic regulator (LQR) to stabilize and improve the performance of aircraft and spacecraft
17. Design a state-observer for the reconstruction of state variables
18. Utilize modern tools such as MATLAB and Simulink for designing aircraft and spacecraft control systems and analyzing their performance**.**

Grading:

Homework and Lab Assignments:	400 points
Midterm Exam 1:	150 points
Midterm Exam 2:	150 points
Final Exam:	300 points
Total:	1000 points

Letter Grade Determination:

Total ≥ 950 points: A+
Total ≥ 900 points: A
Total ≥ 850 points: A-
Total ≥ 800 points: B+
Total ≥ 750 points: B
Total ≥ 700 points: B-

Total ≥ 670 points: C+
Total ≥ 650 points: C
Total ≥ 630 points: C-
Total ≥ 600 points: D
Total < 600 points: F

Notes:

1. All examinations must be taken in order to receive a passing grade.

2. No make-up examinations will be granted without a valid reason and proof.

3. Late assignment submissions will not be accepted.

4. Homework assignments will be posted to Canvas and due to Canvas (using Canvas assignment submission) by the announced due dates. **Please remember to check Canvas for important class announcements**. For analytical problems, please remember to type or scan your work and submit it as a PDF file to Canvas. For computational problems, please remember to publish all MATLAB-Simulink programs to a PDF file and submit it to Canvas.

5. Homework assignments are individual-effort assignments. Students are encouraged to have intellectual discussions about the homework problems. However, all students must prepare and submit their own solutions to the homework problems which reflect their understanding and problem-solving methodologies. Any form of cheating or plagiarism such as copied/shared solutions or code will not be tolerated.

SJSU & AE Department Policies:

- Per University Policy S16-9, university-wide policy information relevant to all courses, such as academic integrity, accommodations, etc. will be available on Office of Graduate and Undergraduate Programs' Syllabus Information web page at <http://www.sjsu.edu/gup/syllabusinfo/>.

- AE Department and SJSU policies are also posted at <http://www.sjsu.edu/ae/programs/policies>.

Approximate Schedule

Week/Dates	Discussions Topics/Class Activities
Week 1 Th 01/23	Welcome to AE 157
Week 2 T 01/28 & Th 01/30	Introduction to Control Engineering
Week 3 T 02/04 & Th 02/06	Fundamentals of Dynamic Systems Modeling and Simulation with MATLAB-Simulink
Week 4 T 02/11 & Th 02/13	Laplace Transform
Week 5 T 02/18 & Th 02/20	Mathematical Modeling of Control Systems
Week 6 **T 02/25** & **Th 02/27**	**Review for Midterm Exam 1 on Tue 02/25** **In-Class Midterm Exam 1 on Thu 02/27 10:30 am-11:45 am**
Week 7 T 03/03 & Th 03/05	Transient Response Analysis Routh's Stability Criterion
Week 8 T 03/10 & Th 03/12	Control Systems Analysis and Design by the Root-Locus Method
Week 9 T 03/17 & Th 03/19	Control Systems Analysis and Design by the Frequency-Response Method
Week 10 T 03/24 & Th 03/26	PID Control System Design and Analysis
Week 11 **T 03/31 & Th 04/02**	**Spring Recess**
Week 12 **T 04/07** & **Th 04/09**	**Review for Midterm Exam 2 on Tue 04/07** **In-Class Midterm Exam 2 on Thu 04/09 10:30 am-11:45 am**
Week 13 T 04/14 & Th 04/16	State-Space Modeling of Dynamic Systems The State-Transition Matrix
Week 14 T 04/21 & Th 04/23	Controllability and Observability State-Feedback Control System Design
Week 15 T 04/28 & Th 04/30	Optimal Control System Design
Week 16 T 05/05 & **Th 05/07**	State Observer Design for the Reconstruction of State Variables **Review for Final Exam on Thu 05/07.**
Final Exam Week **Mon 05/18**	**Final exam is scheduled on Mon 05/18 09:45 am-12:00 pm at ENG 331.**