AE 245 - Spacecraft Dynamics and Control, Spring 2020

Instructor Information:	Professor Long Lu Long.Lu@sjsu.edu
Credit:	3 units
Class Times & Locations:	Tue and Thu 6:00 PM-7:15 PM at ENG 401
Office Hours & Locations:	Tue and Thu 5:00 PM-6:00 PM at ENG 164C
Prerequisites:	BSAE or Instructor Consent
Main Textbook:	Wie, B. *Space Vehicle Dynamics and Control*. AIAA.
Additional References:	[1] Sidi, M. J. *Spacecraft Dynamics and Control: A Practical Engineering Approach*. Cambridge University Press. [2] Curtis, H. *Orbital Mechanics for Engineering Students*. Elsevier Butterworth-Heinemann. [3] Thomson, W. T. *Introduction to Space Dynamics*. Dover Publications. [4] Nelson, R. C. *Flight Stability and Automatic Control*. McGraw-Hill Education. [5] Ogata, K. *Modern Control Engineering*. Pearson.

Course Description:

Rigid body dynamics review. Attitude kinematical representations. Development and solution of general equations of motion. Single and dual-spin, zero and biased-momentum spacecraft. Control system design strategies. Common torquer elements. Computer simulations.

Course Goals:

Introduce students to:

1. Fundamental knowledge of rotational kinematics and rigid body dynamics
2. Space vehicles dynamics and motions
3. Modern control system analysis and design techniques
4. Development of optimal spacecraft control strategies

Course Learning Objectives:

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

1. Derive the governing equations of motion for a rigid-body spacecraft
2. Mathematically model a spacecraft as a dynamical system
3. Utilize state-space representation for system analysis
4. Determine the eigenvalues and eigenvectors of the state matrix of a state-space system
5. Derive the state-transition matrix by the Laplace transformation technique and the exponential method
6. Utilize the state-transition matrix to investigate the response of the system to an input
7. Perform canonical transformations of the system to examine the characteristics of a state equation
8. Analyze the controllability and observability of a spacecraft system
9. Use modern control design techniques to design spacecraft control systems
10. Design an optimal control system to stabilize a spacecraft
11. Reconstruct state variables by designing a state observer
12. Utilize gravity gradient and spin stabilization methods
13. Implement quaternion feedback control method
14. Use reaction wheels and thrusters for attitude control
15. Analyze the spacecraft structural dynamics and the effect of liquid sloshing
16. Utilize modern tools such as MATLAB and Simulink for designing spacecraft control systems and analyzing their performance

Grading:

Homework assignments:	400 points
Midterm examination:	300 points
Final examination:	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 245
Week 2 T 01/28 & Th 01/30	Mathematical Modeling of Dynamical Systems Introduction to Modeling and Simulation with MATLAB-Simulink
Week 3 T 02/04 & Th 02/06	State-space Representation of Control Systems
Week 4 T 02/11 & Th 02/13	State-space System Analysis: Controllability and Observability
Week 5 T 02/18 & Th 02/20	Feedback Control System Design
Week 6 T 02/25 & Th 02/27	Optimal Feedback Control System Design
Week 7 T 03/03 & Th 03/05	State Observer Design for the Reconstruction of State Variables
Week 8 T 03/10 & Th 03/12	Rotational Kinematics
Week 9 T 03/17 & Th 03/19	Rigid Body Dynamics
Week 10 **T 03/24** & **Th 03/26**	**Review for Midterm Exam on Tue 03/24** **In-Class Midterm Exam on Thu 03/26 6:00 PM-7:15 PM**
Week 11 **T 03/31 & Th 04/02**	**Spring Recess**
Week 12 T 04/07 & Th 04/09	Gravity Gradient Stabilization
Week 13 T 04/14 & Th 04/16	Gravity Gradient Stabilization (cont.) Quaternion Feedback Control
Week 14 T 04/21 & Th 04/23	Quaternion Feedback Control (cont.) Attitude Control Using Reaction Wheels
Week 15 T 04/28 & Th 04/30	Attitude Control Using Reaction Wheels (cont.) Reaction Thruster Attitude Control
Week 16 T 05/05 & **Th 05/07**	Reaction Thruster Attitude Control (cont.) **Review for Final Exam on Thu 05/07**
Week 17 **Thu 05/14**	**Final exam is scheduled on Thu 05/14 5:15 pm-7:30 pm at ENG 401.**