AE 245 - Spacecraft Dynamics and Control, Spring 2021

Instructor Information:	Professor Long Lu Long.Lu@sjsu.edu
ISA (Grader):	Gregory Kessing
Credit:	3 units
Class Times & Locations:	Tue and Thu 6:00 PM-7:15 PM on Zoom
Office Hours & Locations:	Fri 7:30 PM-9:30 PM on Zoom
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.

Zoom Meeting Links and Course Materials

Zoom meeting links and course materials such as the syllabus, lecture notes, homework assignments and solutions,... will be available on Canvas. You are responsible for regularly checking Canvas to learn of any updates and announcements. For help with using Canvas, please see Canvas Student Resources page.

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 control system
3. Utilize state-space representations for analysis and design
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 matrix exponential method
6. Utilize the state-transition matrix to study the response of a spacecraft system to an input
7. Perform canonical transformations of a state-space system to examine its characteristics
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 stabilization method
13. Implement quaternion feedback control method to improve the stability and performance of an spacecraft
14. Use reaction wheels and thrusters for spacecraft attitude control
15. Utilize modern tools such as MATLAB and Simulink for spacecraft control system design and analysis.

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

Important 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 on Canvas. **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 01/28	Welcome to AE 245
Week 2 T 02/02 & Th 02/04	Mathematical Modeling of Dynamical Systems Modeling and Simulation with MATLAB-Simulink
Week 3 T 02/09 & Th 02/11	State-Space Representation of Control Systems
Week 4 T 02/16 & Th 02/18	Solutions of State-Space Models State-Space System Analysis
Week 5 T 02/23 & Th 02/25	Controllability and Observability Feedback Control System Design
Week 6 T 03/02 & Th 03/04	Optimal Feedback Control System Design
Week 7 T 03/09 & Th 03/11	State Observer Design for the Reconstruction of State Variables
Week 8 T 03/16 & Th 03/18	Rotational Kinematics
Week 9 **T 03/23 & Th 03/25**	**Midterm Exam Review on Tue 03/23** **Midterm Exam on Thu 03/25 6:00 PM-7:15 PM**
Week 10 **T 03/30 & Th 04/01**	**Spring Recess**
Week 11 T 04/06 & Th 04/08	Rigid Body Dynamics
Week 12 T 04/13 & Th 04/15	Gravity Gradient Stabilization
Week 13 T 04/20 & Th 04/22	Gravity Gradient Stabilization (cont.) Quaternions
Week 14 T 04/27 & Th 04/29	Quaternion Feedback Control Gyroscopic Attitude Control
Week 15 T 05/04 & Th 05/06	Gyroscopic Attitude Control (cont.) Thruster Attitude Control
Week 16 T 05/11 & **Th 05/13**	Thruster Attitude Control (cont.) **Final Exam Review on Thu 05/13**
Week 17 **Th 05/20**	**Final exam is held on Thu 05/20 5:15 pm-7:30 pm.**