San José State University
Aerospace Engineering Department
AE242: Orbital Mechanics and Mission Design
Spring 2022

Instructor:	Prof. J.M. Hunter
Office Hours Link:	https://sjsu.zoom.us/j/96580183367
Class link:	https://sjsu.zoom.us/j/81685351379?pwd=YlpMQzNrS3lLQXdBZTVNcTBOS3VNQT09
Email:	jeanine.hunter@sjsu.edu
Office Hours:	MW 12:00 – 1:00pm
Class Days/Time:	MW 4:30 – 5:45pm
Prerequisite:	BSAE or Instructor Consent

Course Format

Class Website: https://sjsu.instructure.com Under the courses tab, select this course.

For issues related to Canvas, please contact the eCampus Help Desk. The Help Desk can give technical support for issues encountered in Canvas Courses. Phone: (408) 924-2337
Submit a help ticket using the following URL: https://isupport.sjsu.edu/ecampus/ContentPages/Incident.aspx. While logged into Canvas, click on the word **Help** on the upper right corner of the screen.

Course Description

Two-body problem analysis and orbit design, Kepler's Laws, Keplerian elements, Single-impulse orbit transfers, Hohmann transfers, Circularization, Plane changes, Kepler's Equation, Gibbs' method of orbit determination, Terminal phase rendezvous, Orbital Perturbations including atmospheric drag and Earth oblateness, Planetary sphere of influence, Vector mechanics and relative motion of interplanetary flight, Patched conic trajectory model, Gravity-assist trajectories, Case studies, Introduction to the circular and elliptical restricted three-body problems.

Course Goals

1. *To provide a fundamental knowledge of orbital mechanics.*
2. *To understand the assumptions of the various astrodynamics models.*
3. *To apply the equations of three-dimensional particle dynamics to orbits & trajectories.*
4. *To apply Gibbs' Method of orbit determination.*
5. *To use vector mechanics to model interplanetary flight.*
6. *To design trajectories with the Patched-Conic technique.*
7. *To examine case studies and develop an understanding of optimal orbit design strategies.*
8. *To model the Earth/Moon/spacecraft system using the assumptions of the circular and elliptical restricted three-body problems.*
9. *To create computer algorithms for the above applications.*

Course Learning Outcomes

1. *Derive two-body problem equations of motion.*
2. *Determine why astronauts feel weightless.*
3. *Model two-body orbit as a conic section.*
4. *Solve for velocity variation as a function of position along orbit.*
5. *Define elliptical orbit from burnout conditions.*
6. *Calculate circular velocity and escape velocity as a function of altitude.*
7. *Derive and understand the significance of Kepler's Laws of Planetary Motion.*
8. *Calculate Earth-centered Newtonian position and velocity from Keplerian elements.*
9. *Find time along the orbit (time since periapsis passage) using Kepler's equation.*
10. *Use Gibbs' Method of Orbit Determination with three radius observations.*
11. *Calculate velocity along a hyperbolic orbit, turn angle, aiming radius, hyperbolic excess speed, etc.*
12. *Model orbits from case studies and discuss the tradeoffs made in the design decisions.*
13. *Design single impulse Δv burns for orbit transfers.*
14. *Calculate total Δv for a Hohmann transfer around a single central force body.*
15. *Optimize the circularization maneuver.*
16. *Find wait time and phasing angle for a rendezvous scenario.*
17. *Determine the velocity increment required for a terminal phase rendezvous.*
18. *Design an impulse burn to pivot the orbital plane and calculate the required Δv.*
19. *Compute the sphere of influence of a given central force body.*
20. *Using appropriate reference frames and knowledge of relative motion, design patched conic trajectories for interplanetary travel.*
21. *Design & analyze planetary flyby opportunities for changing heliocentric orbital energy.*
22. *Determine the effect of radius of periapsis variation on heliocentric trajectory.*
23. *Determine the effect of perturbations to an idealized Keplerian orbit: atmospheric drag, Earth oblateness, etc.*
24. *Derive equations of motion for the circular restricted three body problem and solve simple cases.*

Required Texts

Hunter: *Astrodynamics Course Reader* (Maple Press)

References

Curtis: *Orbital Mechanics for Engineering Students*
Szebehely: *Adventures in Celestial Mechanics*
Sellers: *Understanding Space*
Thomson: *Introduction to Space Dynamics*
Sidi: *Spacecraft Dynamics and Control*
Bate, Mueller & White: *Fundamentals of Astrodynamics*
Vallado: *Fundamentals of Astrodynamics and Applications*
Wie: *Space Vehicle Dynamics and Control*

Course Requirements and Assignments

Homework	10%
Daily Problems	10%
Daily Problem Team Participation	10%
Project & Presentation	30%
Paper Review	5%
Oral Midterm	15%
Oral Final Exam	20%

Reading assignments will be posted for most classes and should be completed before coming to class. Homework problems will be assigned every week or two. These homework sets are essential to your understanding. Allow 8 – 10 hours per week for homework. Often we will work problems in groups during the class period, sometimes for credit, sometimes not. As homework is graded, I will post the solutions on Canvas and work selected problems on the board. If there is a particular problem that you would like to see worked out, please let me know and I will be sure to make time to do this.

Determination of Grades

Grading Scale: 100 – 97% A plus; 96.9 – 93% A; 92.9 – 90% A minus; 89.9 – 87% B plus; 86.9 – 83% B; 82.9 – 80% B minus; 79.9 – 77% C plus; 76.9 – 73% C; 72.9 – 70% C minus; 69.9 – 67% D plus; 66.9 – 63% D; 62.9 – 60% D minus; < 59.9% F.

Late Homework Policy: Homework is due at the beginning of class on Canvas.
Late homework will be accepted for 70% credit on Canvas until 11:59pm on the due date.

Course Schedule

Week	Lecture Outline
1	The Two-Body Problem
2	Orbit Energy & Relationship to Orbit Type
3	Kepler's Laws of Planetary Motion
4	Keplerian Elements
5	Orbit Determination from Observations
6	Hyperbolic Trajectory Design
7	Planar Orbital Maneuvers
8	Plane Change Maneuver & Rendezvous Phasing
9	Terminal Phase Rendezvous
10	Patched Conic Trajectory Design
11	Gravity Assist Maneuvers
12	Orbital Perturbations: Atmospheric Drag, J_2
13	Circular Restricted Three-Body Problem
14	Lagrange Points
15	Case Studies
16	Final Exam Review

University Policies

Dropping and Adding Students are responsible for understanding the policies and procedures about add/drop, grade forgiveness, etc. Refer to the current semester's Catalog Policies section at http://info.sjsu.edu/static/catalog/policies.html. Add/drop deadlines can be found on the current academic calendar web page located at http://www.sjsu.edu/academic_programs/calendars/academic_calendar/. The Late Drop Policy is available at http://www.sjsu.edu/aars/policies/latedrops/policy/. Students should be aware of the current deadlines and penalties for dropping classes. Information about the latest changes and news is available at the Advising Hub at http://www.sjsu.edu/advising/.

Academic Integrity Your commitment as a student to learning is evidenced by your enrollment at San Jose State University. The University's Academic Integrity policy, located at http://www.sjsu.edu/senate/S07-2.htm, requires you to be honest in all your academic course work. Faculty members are required to report all infractions to the office of Student Conduct and Ethical Development. The Student Conduct and Ethical Development website is available at http://www.sa.sjsu.edu/judicial_affairs/index.html.

Instances of academic dishonesty will not be tolerated. Cheating on exams or plagiarism (presenting the work of another as your own, or the use of another person's ideas without giving proper credit) will result in a *failing grade for the course* and sanctions by the University. For this class, all assignments are to be completed by the individual student unless otherwise specified. If you would like to include your assignment or any material you have submitted, or plan to submit for another class, please note that SJSU's Academic Policy S07-2 requires approval of instructors.

Campus Policy in Compliance with the American Disabilities Act If you need course adaptations or accommodations because of a disability, or if you need to make special arrangements in case the building must be evacuated, please make an appointment with me as soon as possible, or see me during office hours. Presidential Directive 97-03 requires that students with disabilities requesting accommodations must register with the Disability Resource Center (DRC) at http://www.drc.sjsu.edu/ to establish a record of their disability.

Time Required Success in this course is based on the expectation that students will spend, for each unit of credit, a minimum of forty-five hours over the length of the course (normally 3 hours per unit per week with 1 of the hours used for lecture) for instruction or preparation/ studying or course related activities including but not limited to internships, labs, clinical practica. Other course structures will have equivalent workload expectations as described in the syllabus.