San José State University
Aerospace Engineering
AE 242, Orbital Mechanics and Mission Design, Fall, 2020

Course and Contact Information

Instructor(s):	Dr. Lucía Capdevila
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Office Hours:	Tuesdays and Thursdays 15:00 – 16:00
Class Days/Time:	Tuesdays and Thursdays 18:00 – 19:15
Classroom:	Canvas course website
Prerequisites:	BSAE or Instructor Consent

Course Description

Two-body problem, conic sections, time of flight. Gibb's method of orbit determination, maneuver analysis for Earth orbiters and interplanetary flight. Euler-Hill equations. Mission design constraints on orbit geometry and launch window analysis.

Course Format

Technology Intensive, Hybrid, and Online Courses

This course adopts an online delivery format with synchronous online meetings. The course will also be taught in a flipped classroom format where students will be expected to complete readings before attending class meetings. Students will require internet connectivity and access to a computer to participate in classroom activities and submit assignments.

Faculty Web Page and MYSJSU Messaging

Course materials such as syllabus, handouts, notes, assignment instructions, etc. can be found on Canvas Learning Management System course login website at http://sjsu.instructure.com. You are responsible for regularly checking with the messaging system through Canvas to learn of any updates. For help with using Canvas see Canvas Student Resources page (http://www.sjsu.edu/ecampus/teaching-tools/canvas/student_resources) If I cannot reach you via Canvas messaging, I will email you at the address provided in MySJSU.

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 (CLO)

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

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 delta-v burns for orbit transfers.
14. Calculate total delta-v 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 delta-v.
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/Readings

Textbook

Hunter, J. Astrodynamics Course Reader. Maple Press

References

Curtis, H. (2009). Orbital Mechanics for Engineering Students (Elsevier aerospace engineering series). GB: Butterworth Heinemann.

Szebehely, V. (1989). Adventures in celestial mechanics: A first course in the theory of orbits (1st ed.). Austin, Tex.: University of Texas Press.

Szebehely, V. (1967). Theory of orbits, the restricted problem of three bodies. New York: Academic Press.

Roy, A. (1982). *Orbital motion* (2nd ed.). Bristol: A. Hilger.

Thomson, W. (1961). Introduction to space dynamics. New York: Wiley.

Sidi, M. (1997). Spacecraft dynamics and control: A practical engineering approach (Cambridge aerospace series ; 7). Cambridge ; New York: Cambridge University Press.

Bate, Mueller, White, Mueller, Donald D., & White, Jerry E. (1971). Fundamentals of astrodynamics (Dover books on astronomy). New York: Dover Publications.

Vallado, D., & McClain, W. (2001). Fundamentals of astrodynamics and applications (2nd ed., Space technology library ; v. 12). Dordrecht ; Boston: Kluwer Academic.

Wie, B. (2008). Space vehicle dynamics and control (2nd ed., AIAA education series). Reston, Va.: American Institute of Aeronautics and Astronautics.

Course Requirements and Assignments

Success in this course is based on the expectation that students will spend, for each unit of credit, a minimum of 45 hours over the length of the course (normally three hours per unit per week) for instruction, preparation/studying, or course related activities, including but not limited to internships, labs, and clinical practica. Other course structures will have equivalent workload expectations as described in the syllabus.

Students are expected to attend class prepared by having completed pre-lecture activities including readings that will be posted on our Canvas course website. During class, students may take a quiz over the assigned reading, we will go over important and/or difficult points and work on problems for credit. Students will be assigned homework problems on a weekly or bi-weekly basis. Mid-term exams will take place during class meetings.

Final Examination or Evaluation

A comprehensive final exam will be given during our class' final exam slot.

Grading Information

Determination of Grades

- Grade Scale:
    - 100 to 97% A plus

- less than 97% and above or equal to 93% A
- less than 93% and above or equal to 90% A minus
- less than 90% and above or equal to 87% B plus
- less than 87% and above or equal to 83% B
- less than 83% and above or equal to 80% B minus
- less than 80% and above or equal to 77% C plus
- less than 77% and above or equal to 73% C
- less than 73% and above or equal to 70% C minus
- less than 70% and above or equal to 67% D plus
- less than 67% and above or equal to 63% D
- less than 63% and above or equal to 60% D minus
- less than 60% F

- Grade Components Weight:
  - Class participation (Quizzes and/or In-Class Activities): 10 %
  - Homework assignments: 30 %
  - Exams: 60 %

- Students may calculate their current grade in the class by following the "grade scale" and "grade components weight" described above.
  1. Add all the points earned in a given category, divide by the total points possible, and multiply by the component weight.
  2. Repeat step 1 for all grade components.
  3. Add all grade components together.
  4. Determine grade by referring to "grade scale".

  Example:
  Suppose a student has completed 5 assignments so far and earned the grades listed next to the assignment names: Quiz 1: 10/10, In-Class Activity 1: 5/5, Homework 1: 85/100, Homework 2: 95/100, Exam 1: 90/100. Then, applying grade component weights above, the *current grade* calculation is as follows: (10%)(10 +5)/(10 + 5) + (30%)(85+95)/(100+100) + (60%)(90)/(100) = 91%
  Then, by comparing the resulting percentage to the grade scale above, the student's *current grade* corresponds to an A minus.

- All exams must be taken to receive a passing grade.
- All assignments will be submitted via *Canvas at http://sjsu.instructure.com* by the due date posted on Canvas.
- Late work is not accepted for credit without a valid justification and proper documentation.
- Extra credit opportunities will be announced during class.

Classroom Protocol

It is expected that everyone will treat each other and themselves with the highest respect at all times. We all benefit from each other's contributions to the class, so everyone's timely attendance and participation are also expected.

University Policies

Each student is responsible for understanding the following information and let me know if you have any questions:

- Academic Integrity Policy F15-7 at https://www.sjsu.edu/senate/docs/F15-7.pdf

- Student Conduct and Ethical Development at https://www.sjsu.edu/studentconduct/
- AE Program Policies at http://www.sjsu.edu/ae/programs/policies/
- Accessibility: If you need course adaptations or accommodations because of a disability, or if you need 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 AEC to establish a record of their disability.

AE 242 / Orbital Mechanics & Mission Design, Fall 2020, Course Schedule

The following is an *approximate* course schedule that is subject to change with fair notice given during class and/or via email and/or Canvas messaging.

Course Schedule

Week	Date	Topics
1	Thursday, August 20, 2020	Intro. & orientation
2	Tuesday, August 25, 2020	Two-body problem
2	Thursday, August 27, 2020	Two-body problem
3	Tuesday, September 1, 2020	Orbit Energy & Relationship to Orbit Type
3	Thursday, September 3, 2020	Orbit Energy & Relationship to Orbit Type
4	Tuesday, September 8, 2020	Kepler’s Laws of Planetary Motion
4	Thursday, September 10, 2020	Kepler’s Laws of Planetary Motion
5	Tuesday, September 15, 2020	Keplerian Elements
5	Thursday, September 17, 2020	Keplerian Elements
6	Tuesday, September 22, 2020	Orbit Determination from Observations
6	Thursday, September 24, 2020	Orbit Determination from Observations
7	Tuesday, September 29, 2020	Exam 1
7	Thursday, October 1, 2020	Hyperbolic Trajectory Design
8	Tuesday, October 6, 2020	Hyperbolic Trajectory Design
8	Thursday, October 8, 2020	Planar Orbital Maneuvers
9	Tuesday, October 13, 2020	Planar Orbital Maneuvers
9	Thursday, October 15, 2020	Plane Change Maneuver & Rendezvous Phasing
10	Tuesday, October 20, 2020	Plane Change Maneuver & Rendezvous Phasing
10	Thursday, October 22, 2020	Terminal Phase Rendezvous
11	Tuesday, October 27, 2020	Terminal Phase Rendezvous
11	Thursday, October 29, 2020	Lambert's Problem
12	Tuesday, November 3, 2020	Exam 2
12	Thursday, November 5, 2020	Lambert's Problem
13	Tuesday, November 10, 2020	Patched Conic Trajectory Design

Week	Date	Topics
13	Thursday, November 12, 2020	Patched Conic Trajectory Design
14	Tuesday, November 17, 2020	Gravity Assist Maneuvers
14	Thursday, November 19, 2020	Gravity Assist Maneuvers
15	Tuesday, November 24, 2020	Orbital Perturbations
15	Thursday, November 26, 2020	Thanksgiving Holiday - Campus Closed
16	Tuesday, December 1, 2020	Orbital Perturbations
16	Thursday, December 3, 2020	Intro. to the Circular Restricted Three-Body Problem
Final Exam	Thursday, December 10, 2020 17:15-19:30	Final Exam