# AE 142 - Astrodynamics

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| **Instructor Information:** | Professor Long Lu<br>Long.Lu@sjsu.edu |
| **Credit:** | 3 units |
| **Class Times & Locations:** | MW 9:00 – 10:15 am Engr. 327 |
| **Office Hours & Locations:** | MW 8:00 – 9:00 am Engr. 327 |
| **Prerequisites:** | "C-" or better in AE 138 and AE 165 |
| **Main Textbook:** | Hunter, J. M. *Astrodynamics Course Reader*. Maple Press. |
| **Additional References:** | [1] Anderson, J. *Introduction to Flight*. McGraw-Hill Education.<br>[2] Curtis, H. *Orbital Mechanics for Engineering Students*. Elsevier Butterworth-Heinemann. |

**SJSU Catalog Course Description:**

Two-body problem analysis and orbit design; Kepler's Laws; Single-impulse orbit transfers; Hohmann transfers; Circularization; Plane changes; Kepler's Equation; Planetary sphere of influence; Vector mechanics and relative motion of interplanetary flight; Patched conic trajectory model; Gravity-assist trajectories; Case studies; Restricted three-body problem.

**Course Goals:**

Introduce students to:

1. Fundamental knowledge of orbital mechanics
2. Various astrodynamics models and their assumptions
3. Application of three-dimensional particle dynamics equations to orbits and trajectories
4. Modeling interplanetary flight by vector mechanics
5. Examination of case studies and development of optimal orbit design strategies
6. The restricted three-body problem to model the Earth-Moon-spacecraft system

**Course Learning Objectives:**

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

1. Derive equations of motion for the two-body problem and model a two-body orbit as a conic section
2. Find velocity variation as a function of position along an orbit
3. Use burnout conditions to define elliptical orbits
4. Determine orbits from two observations
5. Compute circular and escape velocities as a function of altitude
6. Derive Kepler's Laws of Planetary Motion and understand their significance
7. Find Earth-centered Newtonian position and velocity from Keplerian elements
8. Calculate time since periapsis passage using Kepler's equation
9. Compute velocity along a hyperbolic orbit, turn angle, aiming radius, hyperbolic excess speed, etc.
10. Investigate case studies to model orbits and discuss the tradeoffs in the design process
11. Design single impulse $\Delta v$ burns for orbit transfers
12. Calculate total $\Delta v$ for a Hohmann transfer around a single central force body
13. Design the optimal circularization maneuvers
14. Calculate wait time and phasing angle for a rendezvous scenario
15. Design an impulse burn to pivot the orbital plane and calculate the required $\Delta v$
16. Compute the sphere of influence of a given central force body
17. Use appropriate reference frames and knowledge of relative motion and design patched conic trajectories for interplanetary travel
18. Design and analyze planetary flyby opportunities for changing heliocentric orbital energy
19. Derive equations of motion for the restricted three body problem
20. Work effectively in teams to define, propose, and solve an astrodynamics problem incorporating the use of modern computational tools such as MATLAB/Simulink

**Grading:**

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|---|---|---|
| Homework assignments: | | 400 points |
| Exam 1: | | 150 points |
| Exam 2: | | 150 points |
| Course project: | | 300 points |
| • Project proposal presentation: | 50 points | |
| • Final project presentation: | 50 points | |
| • Final project report: | 200 points | |
| Total: | | 1000 points |

**Letter Grade Determination:**

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|---|---|
| ≥ 950 points: A+ | ≥ 670 points: C+ |
| ≥ 900 points: A | ≥ 650 points: C |
| ≥ 850 points: A- | ≥ 630 points: C- |
| ≥ 800 points: B+ | ≥ 600 points: D |
| ≥ 750 points: B | < 600 points: F |
| ≥ 700 points: B- | |

**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 at the beginning of class on the announced due dates.

5. Homework assignments are individual effort assignments. Students are encouraged to discuss how to solve homework problems. However, all students must prepare and submit their own solutions to the homework problems which reflect their understanding and problem-solving methodology. Any form of cheating or plagiarism will not be tolerated.

6. For the course projects, students will work in teams of no more than 4 members to define, propose, and solve an astrodynamics problem incorporating the use of modern computational tools such as MATLAB/Simulink.

7. The final project reports must be typewritten and follow the AIAA technical conference paper format.

8. Further details regarding the course project will be discussed in class.

**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 | Discussion Topics/Class Activities |
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| 1 | Wed 01/24 | Welcome to AE 142 |
| 2 | Mon 01/29 & Wed 01/31 | Motion under a Central Force: The Restricted Two- Body Problem |
| 3 | Mon 02/05 & Wed 02/07 | Orbit Energy |
| 4 | Mon 02/12 & Wed 02/14 | Kepler's Laws of Planetary Motion |
| 5 | Mon 02/19 & Wed 02/21 | Kepler's Laws of Planetary Motion (cont.)<br>Team announcements are due to Canvas by 11:59 PM Wed 02/21. |
| 6 | Mon 02/26 & Wed 02/28 | The Six Keplerian Elements |
| 7 | Mon 03/05 & Wed 03/07 | The Six Keplerian Elements (cont.) |
| 8 | Mon 03/12 & Wed 03/14 | Exam 1 review on Mon 03/12<br>Exam 1 on Wed 03/14 |
| 9 | Mon 03/19 & Wed 03/21 | Project Proposal Presentations |
| 10 | Mon 03/26 & Wed 03/28 | Spring Recess |
| 11 | Mon 04/02 & Wed 04/04 | Geometry of a Hyperbolic Trajectory |
| 12 | Mon 04/09 & Wed 04/11 | Orbital Maneuvers |
| 13 | Mon 04/16 & Wed 04/18 | Interplanetary Trajectories |
| 14 | Mon 04/23 & Wed 04/25 | The Three-Body Problem |
| 15 | Mon 04/30 & Wed 05/02 | Exam 2 review on Mon 04/30<br>Exam 2 on Wed 05/02 |
| 16 | Mon 05/07 & Wed 05/09 | Final Project Presentations |
| 17 | Mon 05/14 & Tue 05/15 | No class on Mon 05/14. Please work on the final project report.<br>Final project reports and code folders are due to Canvas by 11:59 PM Tue 05/15. |