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

Course and Contact Information

Instructor(s): Dr. Lucía Capdevila
Office Location: Engineering building 272 E
Telephone: (408) 924 - 3126
Email: lucia.capdevila@sjsu.edu
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

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.
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


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

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Topics</th>
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<tbody>
<tr>
<td>1</td>
<td>Thursday, August 20, 2020</td>
<td>Intro. &amp; orientation</td>
</tr>
<tr>
<td>2</td>
<td>Tuesday, August 25, 2020</td>
<td>Two-body problem</td>
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<tr>
<td>2</td>
<td>Thursday, August 27, 2020</td>
<td>Two-body problem</td>
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<tr>
<td>3</td>
<td>Tuesday, September 1, 2020</td>
<td>Orbit Energy &amp; Relationship to Orbit Type</td>
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<tr>
<td>3</td>
<td>Thursday, September 3, 2020</td>
<td>Orbit Energy &amp; Relationship to Orbit Type</td>
</tr>
<tr>
<td>4</td>
<td>Tuesday, September 8, 2020</td>
<td>Kepler’s Laws of Planetary Motion</td>
</tr>
<tr>
<td>4</td>
<td>Thursday, September 10, 2020</td>
<td>Kepler’s Laws of Planetary Motion</td>
</tr>
<tr>
<td>5</td>
<td>Tuesday, September 15, 2020</td>
<td>Keplerian Elements</td>
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<tr>
<td>5</td>
<td>Thursday, September 17, 2020</td>
<td>Keplerian Elements</td>
</tr>
<tr>
<td>6</td>
<td>Tuesday, September 22, 2020</td>
<td>Orbit Determination from Observations</td>
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<tr>
<td>6</td>
<td>Thursday, September 24, 2020</td>
<td>Orbit Determination from Observations</td>
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<tr>
<td>7</td>
<td>Tuesday, September 29, 2020</td>
<td>Exam 1</td>
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<tr>
<td>7</td>
<td>Thursday, October 1, 2020</td>
<td>Hyperbolic Trajectory Design</td>
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<tr>
<td>8</td>
<td>Tuesday, October 6, 2020</td>
<td>Hyperbolic Trajectory Design</td>
</tr>
<tr>
<td>8</td>
<td>Thursday, October 8, 2020</td>
<td>Planar Orbital Maneuvers</td>
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<tr>
<td>9</td>
<td>Tuesday, October 13, 2020</td>
<td>Planar Orbital Maneuvers</td>
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<tr>
<td>9</td>
<td>Thursday, October 15, 2020</td>
<td>Plane Change Maneuver &amp; Rendezvous Phasing</td>
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<tr>
<td>10</td>
<td>Tuesday, October 20, 2020</td>
<td>Plane Change Maneuver &amp; Rendezvous Phasing</td>
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<tr>
<td>10</td>
<td>Thursday, October 22, 2020</td>
<td>Terminal Phase Rendezvous</td>
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<tr>
<td>11</td>
<td>Tuesday, October 27, 2020</td>
<td>Terminal Phase Rendezvous</td>
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<tr>
<td>11</td>
<td>Thursday, October 29, 2020</td>
<td>Lambert’s Problem</td>
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<tr>
<td>12</td>
<td>Tuesday, November 3, 2020</td>
<td>Exam 2</td>
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<tr>
<td>12</td>
<td>Thursday, November 5, 2020</td>
<td>Lambert’s Problem</td>
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<tr>
<td>13</td>
<td>Tuesday, November 10, 2020</td>
<td>Patched Conic Trajectory Design</td>
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<tr>
<td>Week</td>
<td>Date</td>
<td>Topics</td>
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<td>13</td>
<td>Thursday, November 12, 2020</td>
<td>Patched Conic Trajectory Design</td>
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<tr>
<td>14</td>
<td>Tuesday, November 17, 2020</td>
<td>Gravity Assist Maneuvers</td>
</tr>
<tr>
<td>14</td>
<td>Thursday, November 19, 2020</td>
<td>Gravity Assist Maneuvers</td>
</tr>
<tr>
<td>15</td>
<td>Tuesday, November 24, 2020</td>
<td>Orbital Perturbations</td>
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<tr>
<td>15</td>
<td>Thursday, November 26, 2020</td>
<td>Thanksgiving Holiday - Campus Closed</td>
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<tr>
<td>16</td>
<td>Tuesday, December 1, 2020</td>
<td>Orbital Perturbations</td>
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<tr>
<td>16</td>
<td>Thursday, December 3, 2020</td>
<td>Intro. to the Circular Restricted Three-Body Problem</td>
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<td>Final Exam</td>
<td>Thursday, December 10, 2020 17:15-19:30</td>
<td>Final Exam</td>
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