San José State University
Aerospace Engineering
AE 247, Trajectory Optimization for Space Applications, 1, Fall, 2021

Course and Contact Information

Instructor(s):	Lucia Capdevila, PhD
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Office Hours:	TBD
Class Days/Time:	TBD
Classroom:	TBD
Prerequisites:	BSAE or Instructor Consent

Course Description

Formulation and solution of optimization problems in aerospace engineering. Parameter optimization, minima of functions and functionals, necessary conditions, calculus of variations, control formulation, two-point boundary-value problems. Primer vector theory. Applications to typical problems in aerospace engineering, such as optimal launch, minimum time to climb, maximum range, and optimal space trajectories.

Course Format

Technology Intensive, Hybrid, and Online Courses

Students will need access to a computer that can access the internet and to run MATLAB (available through SJSU license to everyone at SJSU). Course material will be made available via Canvas, so students need a computer with internet access to effectively participate in the course. Assignments may include numerical calculations that will require programming in MATLAB, so the students will need access to a computer where they can install and run MATLAB.

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. Recognize trajectory optimization problems
2. Formulate trajectory optimization problems
3. Solve for optimal trajectories

Course Learning Outcomes (CLO)

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

1. Formulate and solve parameter optimization problems
2. Formulate and solve the Bolza, Lagrange, and Mayer optimal control problems
3. Derive and apply the Euler-Lagrange theorem
4. Derive and apply necessary and sufficient conditions for optimality
5. Calculate Lawden's primer vector
6. Apply the general theory of optimal rocket trajectories to solve for the thrust profile of a spacecraft trajectory

Required Texts/Readings

Textbook

None

Other Readings

Class notes

References

- Longuski, Guzman & Prussing. Optimal Control with Aerospace Applications. Springer, 2014. (May be available as eBook via MLK)
- Prussing. Optimal Spacecraft Trajectories. Oxford, 2018.
- Bryson and Ho. Applied Optimal Control. Blaisdell, 1969
- Conway (editor). Spacecraft Trajectory Optimization. Cambridge University Press, 2010
- Lawden. Optimal Trajectories for Space Navigation. Butterworths, London, 1963.

Other technology requirements / equipment / material

Students need access to a computer that can connect to the internet and to run MATLAB (available through SJSU license to everyone at SJSU). Course materials will be made available via Canvas, so students need a computer with internet access to effectively participate in the course. Assignments may include numerical calculations that will require programming in MATLAB, so the students will need access to a computer where they can install and run MATLAB.

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 announced during class. 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](http://sjsu.instructure.com) *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

Per University Policy S16-9 *(http://www.sjsu.edu/senate/docs/S16-9.pdf)*, relevant university policy concerning all courses, such as student responsibilities, academic integrity, accommodations, dropping and adding, consent for recording of class, etc. and available student services (e.g. learning assistance, counseling, and other resources) are listed on Syllabus Information web page (http://www.sjsu.edu/gup/syllabusinfo), which is hosted by the Office of Undergraduate Education. Make sure to visit this page to review and be aware of these university policies and resources.

The Aerospace Engineering Department's policies are listed on the AE Program Policies Web Page (http://www.sjsu.edu/ae/programs/policies/)

AE 247 / Trajectory Optimization for Space Applications, Fall 2021, 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/Lesson /Module	**Date**	**Topics** ***(If appropriate, add extra column(s) to meet your needs.)***
1		Parameter optimization vs. functional optimization
1		Parameter optimization
2		Optimal control theory
2		Optimal control theory
3		Euler-Lagrange theorem
3		Euler-Lagrange theorem
4		Euler-Lagrange theorem
4		Euler-Lagrange theorem
5		Applications of the Euler-Lagrange theorem
5		Applications of the Euler-Lagrange theorem
6		Applications of the Euler-Lagrange theorem
6		The Weierstrass necessary condition
7		Exam 1
7		The Weierstrass necessary condition
8		Pontryagin’s minimum principle
8		Legendre-Clebsch necessary condition
9		Necessary and sufficient conditions
9		Examples of the minimum principle
10		Applications in Aerospace
10		Applications in Aerospace
11		Applications in Aerospace
11		Weierstrass-Erdmann Corner conditions
12		Exam 2

Week/Lesson /Module	Date	Topics ***(If appropriate, add extra column(s) to meet your needs.)***
12		Weierstrass-Erdmann Corner conditions
13		Bounded control problems
13		Bounded control problems
14		General theory of optimal rocket trajectories
14		General theory of optimal rocket trajectories
15		General theory of optimal rocket trajectories
15		Thanks Giving – No classes
16		Final exam review
Final Exam		Venue and Time