EN.530.626: Trajectory Generation for Space Systems

Instructor: Prof. Abhishek Cauligi

Semester: Fall 2025

Course Description

This course will provide an introduction to trajectory design techniques for aerospace and spacecraft robotic systems. We will place a heavy emphasis on optimization-based techniques and study optimal control formulations for solving trajectory optimization and model predictive control problems. Applications of interest will include interplanetary trajectory optimization, rocket entry-descent-landing, asteroid proximity operations, and planetary rover path planning. A strong emphasis will be placed on practical applications through coding implementations in Python and evaluation in simple simulation environments. Finally, a course project will be included to allow students to gain further experience on an algorithm or application of their choice.

Prerequisites: A strong foundation in linear algebra and differential equations and experience with a high-level programming language such as Python or Julia will be assumed.

Instructor

Abhishek Cauligi
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Teaching Assistants

Mark Gonzales
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Arnab Chatterjee
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Lectures

Tuesday and Thursday, 1:30-2:45PM in Hodson 216.

Textbook

There is no required textbook for this class.

Office Hours

Office hours will begin in the second week of the semester.
Prof. Cauligi's office hours are on Tuesdays 1:00pm to 2:00pm in Hackerman 117.
Arnab Chatterjee's office hours are on Mondays 3-4PM.
Mark Gonzales's office hours are on Thursdays 11AM-12PM.

Grading Policy

- Assignments: 40%
- Midterm Exam: 30%
- Final Project: 30%

Course Policies

Late Assignments: Late submissions will be penalized by 10% per day.
Academic Integrity: All students must adhere to university policies on plagiarism and cheating.
Attendance: Regular attendance is expected and lectures will not be recorded.

Course Schedule

Week	**Lecture**	**Date**	**Topics Covered**	
1	1	08/26	Intro: linear algebra & differential equations review	
	2	08/28	Linear systems theory	
2	3	09/02	Optimization fundamentals	HW1 Released
	4	09/04	Calculus of variations	
3	5	09/09	Pontryagin's maximum principle and indirect methods	
	6	09/11	Constrained optimization (Pt. 1)	HW1 Due, HW2 Released
4	7	09/16	Constrained optimization (Pt. 2)	Form project groups
	8	09/18	Constrained optimization (Pt. 3)	
5	9	09/23	Off-the-shelf trajectory optimization	
	10	09/25	Planetary entry, descent, and landing	Final project proposal due
6	11	09/30	Rigid bodies and Euler's equation	
	12	10/02	Planning with attitude	HW2 Due, HW3 Released
7	13	10/07	Combinatorial planning via integer programs	
	14	10/09	Sampling-based motion planning	
8	15	10/14	Inverse classroom (mid-semester checkpoint)	
	16	10/16	**No lecture (Fall Break)**	HW3 Due, HW4 Released
9	17	10/21	Derivative-free methods for trajectory optimization	
	18	10/23	Surface rover path planning	
10	19	10/28	Long and short range planner hierarchies	
	20	10/30	Uncertainty propagation	HW4 Due, HW5 Released
11	21	11/04	Stochastic optimal control	
	22	11/06	**Midterm Exam**	
12	23	11/11	Guest lecture (Dr. Bobby Braun)	
	24	11/13	Differentiable MPC	HW5 Due
13	23	11/18	Learning value functions	
	24	11/20	Guest lecture (TBD)	
14	23	11/25	**No Lecture (Thanksgiving Break)**	
	24	11/27	**No Lecture (Thanksgiving Break)**	
15	25	12/02	Final project presentations	
	26	12/04	Final project presentations	Final project report due