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
Email: `cauligi@jhu.edu`

Teaching Assistants

Mark Gonzales
Email: `mgonza60@jhu.edu`

Arnab Chatterjee
Email: `achatt13@jhu.edu`

Lectures

Tuesday and Thursday, 1:30-2:45PM

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	HW1 Released
2	3	09/02	Optimization fundamentals	
	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