# 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 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 Wednesdays 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 | Constrained optimization (Pt. 1) | |
| 3 | 5 | 09/09 | Constrained optimization (Pt. 2) | |
| | 6 | 09/11 | Constrained optimization (Pt. 3) | HW1 Due, HW2 Released |
| 4 | 7 | 09/16 | Calculus of variations | Form project groups |
| | 8 | 09/18 | Pontryagin's maximum principle and indirect methods | |
| 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 | Surface rover path planning | |
| | 18 | 10/23 | Long and short range planner hierarchies | |
| 10 | 19 | 10/28 | Derivative-free methods for trajectory optimization | |
| | 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 |