# Assignment 3: Trajectory Optimization in Joint Space

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## Objective

The objective of this assignment is to introduce trajectory optimization by computing joint-space trajectories that are not only smooth, but also optimal with respect to a chosen performance criterion. Students will learn how to formulate an optimization problem and solve it numerically to generate improved robot motion.

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## Problem Description

Consider the same 2-link planar robotic arm used in previous assignments. The robot must move from an initial joint configuration (q1_start, q2_start) to a final joint configuration (q1_end, q2_end) over a fixed time duration T.
Instead of manually designing the trajectory, you will now compute the trajectory by solving an optimization problem that minimizes a specified cost function while satisfying boundary conditions.

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## Trajectory Parameterization

Discretize the time interval from 0 to T into N equally spaced time steps. At each time step, the joint angles q1 and q2 are treated as decision variables.
The trajectory is defined as the sequence of joint angles over time.

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## Cost Function

Choose one of the following cost functions:

- Minimize the sum of squared joint velocities (energy-efficient motion)
- Minimize the sum of squared joint accelerations (smooth motion)

You may optionally experiment with a weighted combination of both.

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## Constraints

The optimization must satisfy:

- The initial joint angles equal the specified start configuration
- The final joint angles equal the specified end configuration
- (Optional) Joint angle limits

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## Expected Work

Students are expected to:

- Formulate the trajectory optimization problem
- Solve it using a numerical optimization method (such as SciPy’s minimize)
- Generate optimized joint trajectories
- Compare optimized trajectories with the polynomial trajectories from Assignment 2

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## Comparison and Analysis

Students must compare:

- Joint angle profiles
- Smoothness of motion
- Cost values before and after optimization

A brief discussion should explain how optimization improves trajectory quality.

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## Submission Requirements

Each submission must include:

- Python code implementing trajectory optimization
- Plots of optimized joint trajectories
- Comparison plots with polynomial trajectories
- A short written discussion (6–8 sentences)

### Deadline - 2nd January, 2026, for submission follow the same instructions as for Assignment 2