* In homework 7, linear functions with parabolic blends is used for trajectory planning. However, for this homework assignment, I would like to use cubic polynomials as I want to practice it for the upcoming final examination.
* A math equations with numbers and symbols

  Description automatically generatedInputs:
* Desired trajectories for two joints and are as follows:

A graph of a function

Description automatically generated

* Firstly, we do computed torque control to drive the manipulator using the following equation:



As we can see in the below figure, the position errors of two joints are quite large.

A graph of a function

Description automatically generated with medium confidence

* In order to reduce the position error, sliding mode controller is designed as the following:
* Let the sliding surface for joint i be defined as:

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Description automatically generated

Where:

* is the desired joint position
* ​ is the actual joint position of joint i
* is the actual joint velocity
* is a positive constant that determines the speed of reaching the sliding mode
* And the sliding mode controller for joint i is designed as:



Where:

* is a positive gain that determines the robustness of the controller,
* ​ is a positive gain to provide additional stability.

A graph of a function

Description automatically generated with medium confidence

In summary, the position errors are significantly reduced when compared to computed torque control.