Exercise 6.1

Consider the robot manipulator from Lecture 4.

1. Centralized Control
   (a) Design a PD controller with gravity compensation and evaluate it by initializing the robot in $\boldsymbol{q}(0) = (0, 3\pi/2, 3\pi/2)$ and giving a constant setpoint $\boldsymbol{q}_d = (\pi/2, \pi/3, \pi/3)$.
   (b) Compute the value of the Lyapunov function for the system (it is given in the slides) and verify that it is decreasing along the solution trajectory obtained from the previous item 1a.
2. Decentralized Control (Optional)
   (a) Design a decentralized position feedback controller (PI controller) for the robot manipulator and verify its performance on a trajectory starting in $\boldsymbol{q}(0) = (0, 3\pi/2, 3\pi/2)$ and ending in $\boldsymbol{q}(5) = (\pi/2, \pi/3, \pi/3)$
   (b) Add feedforward to the controller and compare its performance with the controller without feedback (compare q_d with q and compare the actuator torques of the two controllers)