Dynamics and Control of Robot-Environment Interaction
(HW 04 Fall 2021)

Due to November 11th, 2021

Problem 4 Control in Joint Space (30)

✓ Consider a 7dof manipulator, which model is given in class. Implement the following controllers in Joint Space.

✓ For each problem choose proper gain.

✓ **Design trajectories to start from initial position,** $q_{int} = [0\,0\,0\,-30^{\circ}\,0\,90^{\circ}\,0]^T$. **(You can use equation (5).)**

1. Design and Implement a simple PD controller.

$$\tau = K_p(q_d - q) + K_v(\dot{q}_d - \dot{q}) \tag{1}$$

   where

$$K_p = diag(K_{p1}, K_{p2}, \ldots, K_{p7}), \quad K_v = diag(K_{v1}, K_{v2}, \ldots, K_{v7}) \tag{2}$$

   - Plot a step response of 5 deg of the Joint 4 (from -30° to -25°). $\dot{q}_d = 0$ for step commands.

2. Design and Implement a simple PD controller with gravity compensation.

$$\tau = K_p(q_d - q) + K_v(\dot{q}_d - \dot{q}) + G \tag{3}$$

   where

$$K_p = diag(K_{p1}, K_{p2}, \ldots, K_{p7}), \quad K_v = diag(K_{v1}, K_{v2}, \ldots, K_{v7}) \tag{4}$$

   - Plot a step response of 5 deg of the Joint 4 (from -30° to -25°). $\dot{q}_d = 0$ for step commands.
   - Plot a result of trajectory tracking of the Joint 4, starting from -30° to -60° using cubic spline.

3. Design and Implement a PD controller with dynamic compensation. Design the controller to have $w_n = 20$ rad/sec and critically damped.

$$\tau = M\{k_p(q_d - q) + k_v(\dot{q}_d - \dot{q})\} + G \tag{5}$$

   - Plot a step response of 5 deg of the Joint 4 (from -30° to -25°). $\dot{q}_d = 0$ for step commands.
   - Plot a result of trajectory tracking of the Joint 4, starting from -30° to -60° using cubic spline.
   - Explain the effect of M matrix.