Sharif University of Technology
Department of Electrical Engineering

Assignment 1
Robot control 1

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Problem 1: Consider the 6-DOF robot shown in the downloadable Brochure.

a. Specify the coordinate frames for the robot.

b. Determine a, α, θ, d parameters for each link.

c. Compute forward kinematics, H_6^0 in the Simulink, numerically.

d. Compute the Jacobian for the EF in the Simulink, numerically.

e. Verify $H_6^0(q)$ by restricting the robot in simple configurations and comparing your physical intuition with numerical simulations. Plot robot configuration for the following configuration vectors and report H_6^0.

Try $q = [0, 0, 0, 0, 0, 0]$, $q = [0, \frac{-\pi}{2}, 0, 0, 0, 0]$, $q = [0, 0, -\frac{\pi}{2}, 0, 0, 0]$,
$q = [0, \frac{\pi}{2}, \frac{\pi}{3}, 0, 0, 0]$, $q = [0, 0, 0, 0, \frac{\pi}{2}, 0]$, $q = [0, \frac{\pi}{2}, 0, -\frac{\pi}{2}, 0, \frac{\pi}{2}]$.

f. Sketch the robot in singular configurations.

g. Verify $J(q)$ for the configurations given in part e.

Assume that motor masses are $m_1 = m_2 = m_3 = 10$kg, $m_4 = m_5 = m_6 = 5$kg. Assume that mass distribution in each motor is symmetric with respect to principle axes. Assume that all the mass in motors is concentrated in rotors which are considered cylindrical. Diameter of rotors are assumed to be the half of entire motor diameter. Assume that links are massless.

h. Compute $M(q), C(q, \dot{q}), g(q)$, numerically.

i. Verify that $M(q)$ is positive definite and $\dot{M} - 2C$ is skew symmetric.

j. Assume that $\dot{q}(0) = 0$ and $q(0) = [0, \frac{\pi}{2}, 0, 0, 0, 0]$ and apply the torques $\tau = g(g) + [\sin(t), 0, 0, 0, 0, 0]$, $\tau = g(q)$, $\tau = 0$, $\tau = g(q) + [0, 0, 0, 0, 0, \sin(t)]$, and plot q, $\dot{q}$ and internal force-torques in each case.
