Assignment 5

For a planar 2-DOF, 2R robot (all revolute joints), with link lengths l_1 and l_2. Joint positions, joint velocities and joint accelerations are denoted as q_i, q_{di} and $q_{ddi,}$ $i=1-2,$ respectively. Also, T_i, $i=1-2$, denote the joint torque values.

Links: $m_1 = m_2 = 1;\quad l_1 = l_2 = 1;\qquad I_1 = I_2 = 1/12;$

Motors: $J_{m1} = J_{m2} = 0.4\times10^{-4}\ (kgm^2);\ K_{m1} = K_{m2} = 2.32\times10^{-2}\ (Nm/A)$

$B_{m1} = B_{m2} = 4.77\times10^{-5}\ (Nm/(rad/sec));\ R_1 = R_2 = 0.365\ (Ohm)$

$K_{b1} = K_{b2} = 0.0232\ (V/(rad/sec));\ r_1 = r_2 = 1/100$

(Trajectory) Plan the desired joint trajectories when the states of the system, $[q_1\ \ q_2\ \ q_{d1}\ \ q_{d2}]$, change from *[0 0 0 0]* at *t = 0 sec* to $[\pi/6\ \pi/3\ 0\ 0]$ at *t =* ***2*** *sec*.

1. **(Multivariable Control)** For the system equation as derived in class, $\boldsymbol{(D+J)\ q_{dd} + C\ q_d + B\ q_d + g = u}$. Use PD compensator to plan the input, *u*, to track the desired joint trajectories. *Do not neglect the gravity terms.* If $\boldsymbol{I}$ is an 2×2 identity matrix then select $K_P = 5\boldsymbol{I}$ and $K_D = 10\boldsymbol{I}$. Use a numerical solver (ode45) for above conditions and parameters to simulate the system performance. Plot, compare and discuss the simulation results with regard to trajectory tracking. Consider at least two different values of K_P and K_D to discuss the role of gains. Animate the 2R manipulator.

2. **(Computed Torque)** For the system equation as derived in class, $\boldsymbol{M\ q_{dd} + h = u}$. Use computed torque method to plan the input, $u = M\ v + h$. Select $v = (q^{desired})_{dd} + K_1\ e_d + K_0\ e$ where $e = q^{desired} - q$. If $\boldsymbol{I}$ is an 2×2 identity matrix then select $K_0 = 25\boldsymbol{I}$ and $K_1 = 10\boldsymbol{I}$. Use a numerical solver (ode45) for above conditions and parameters to simulate the system performance. Plot, compare and discuss the simulation results with regard to trajectory tracking. Consider at least two different values of K_1 and K_0 to discuss the role of gains. Animate the 2R manipulator.

Submit following in a zipped folder:

1. **Matlab program** - should have comments, we will run it to verify your results.
2. **Report** with answers, equations and figures to all above questions.
3. **LaTex file** used for the report.