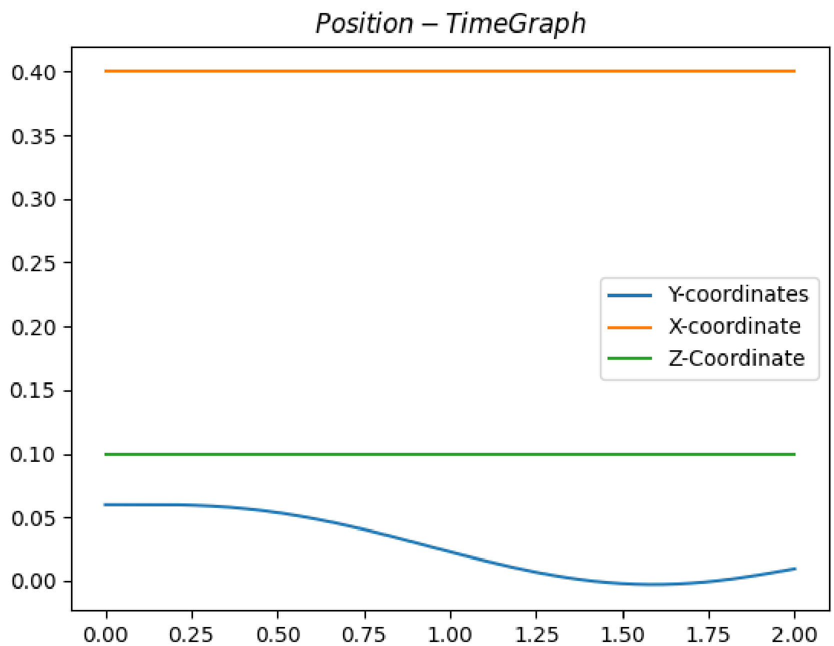
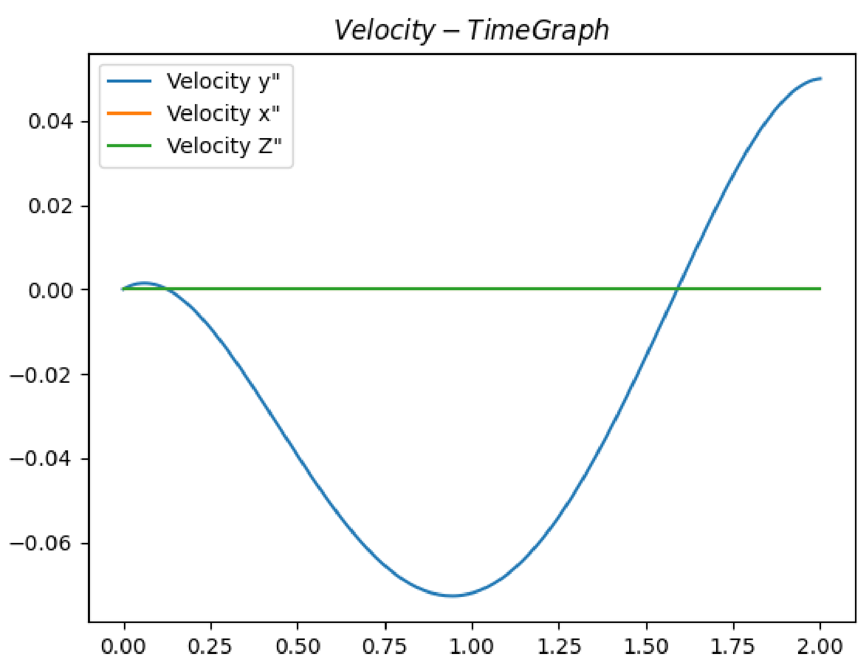
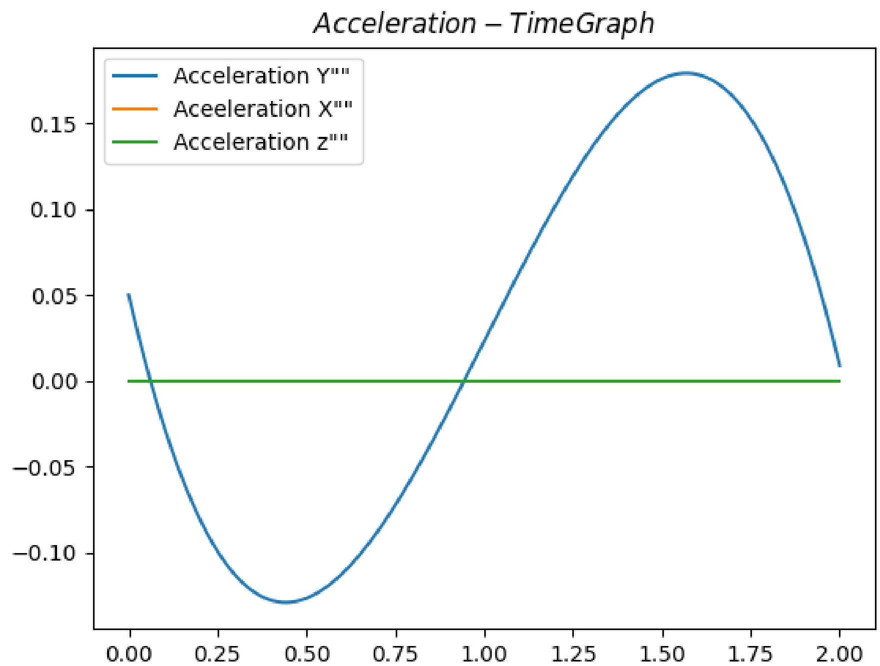
Introduction to Robotics

Assignment 6&7

Task1)

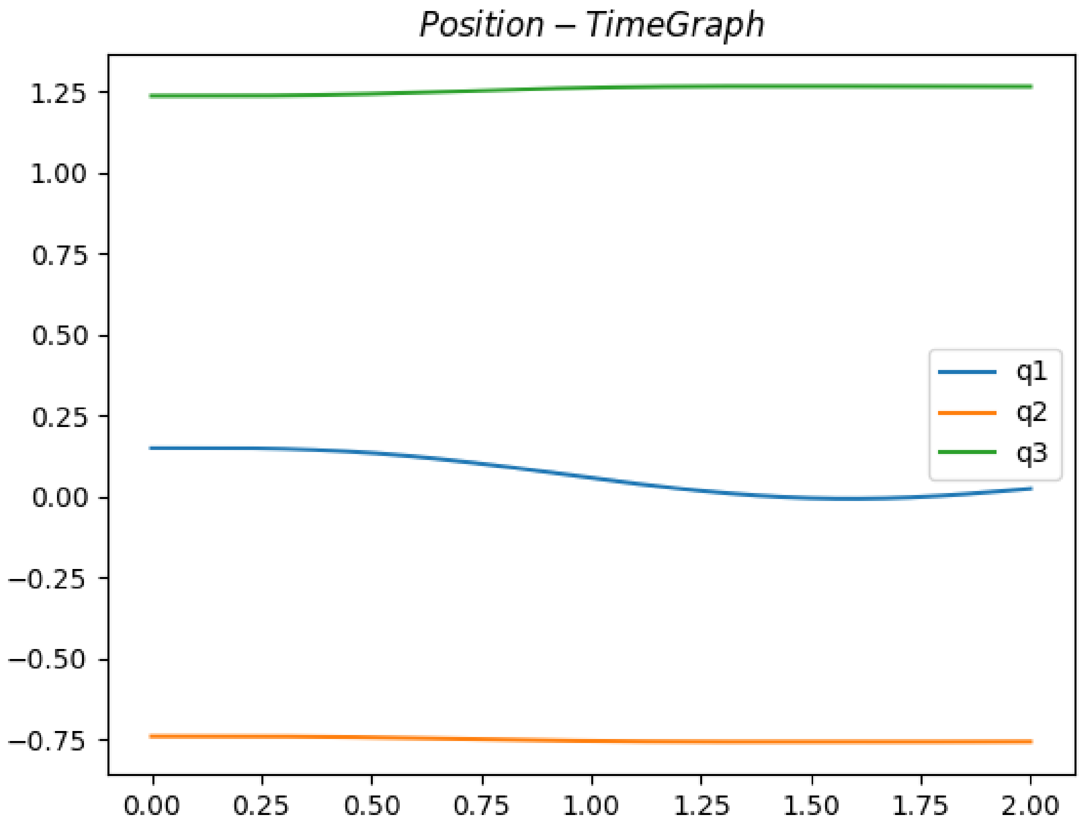




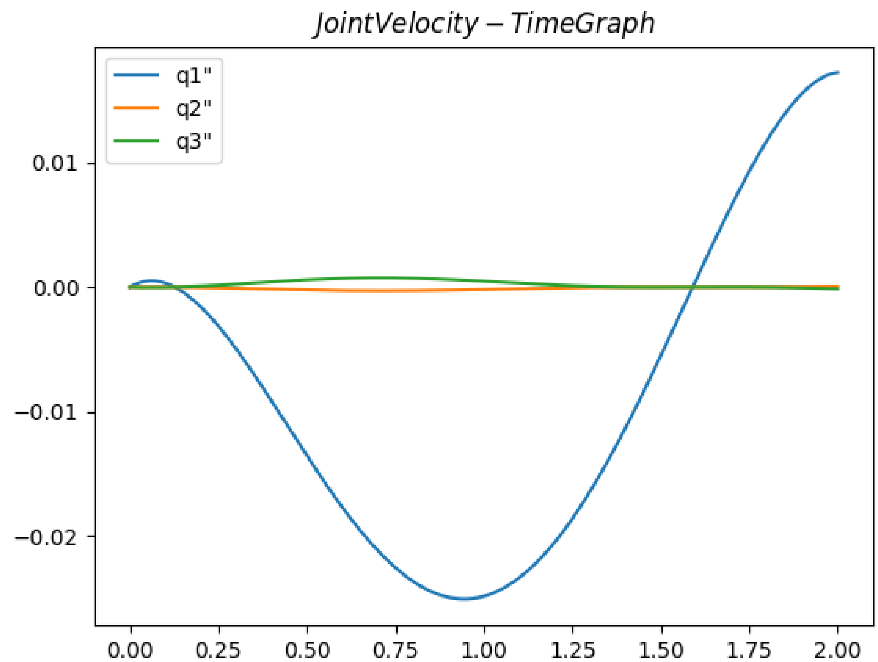


$Acceleration - TimeGraph$
Acceleration Y""
Aceeleration X""
Acceleration z""
0.15
0.10
0.05
0.00
−0.05
−0.10
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

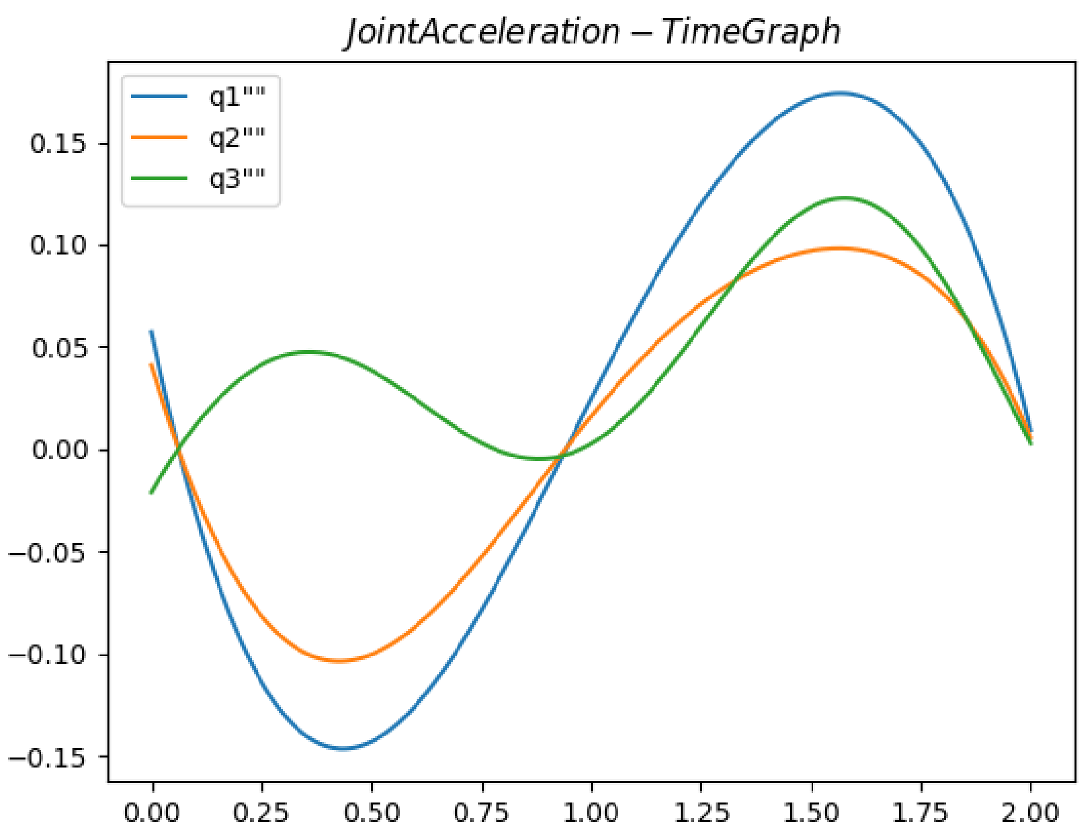
Task 2)



$Position - TimeGraph$
1.25
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
q1
q2
q3

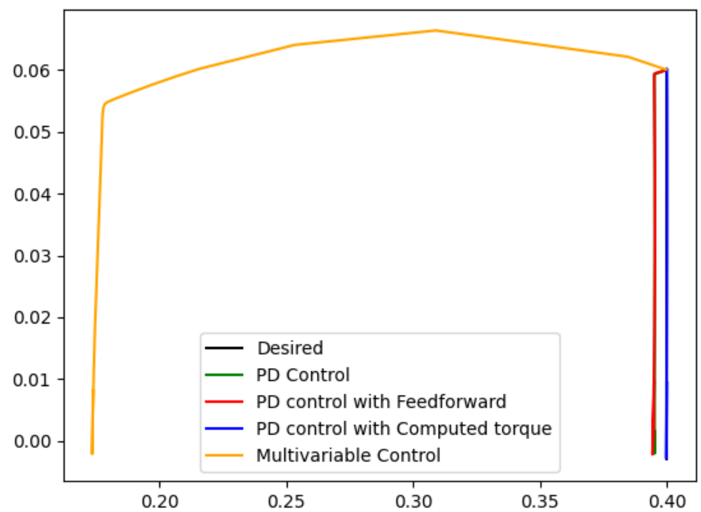


$JointVelocity - TimeGraph$
q1"
q2"
q3"
0.01
0.00
−0.01
−0.02
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

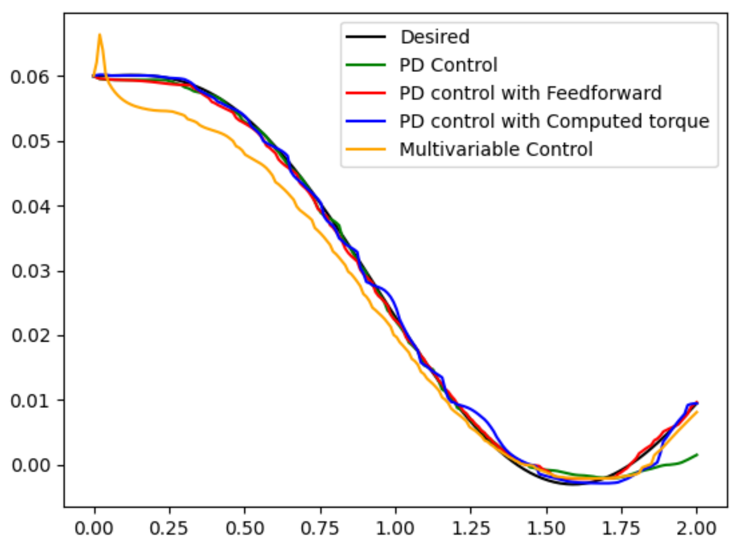


$JointAcceleration - TimeGraph$
q1""
q2""
q3""
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

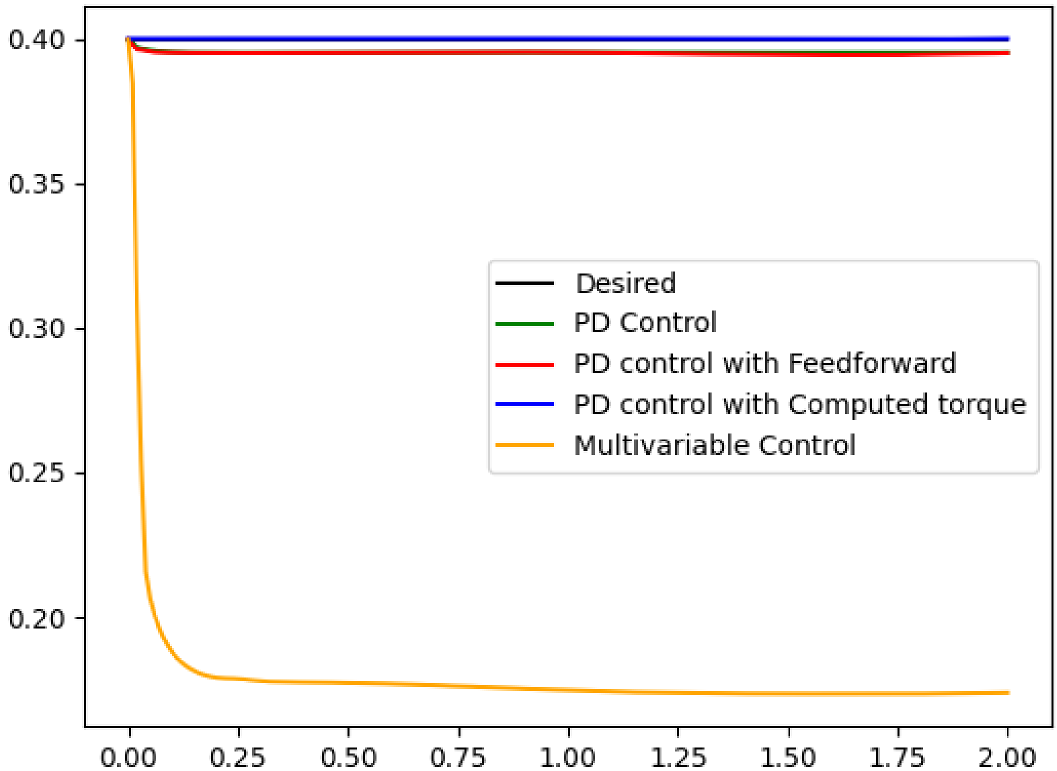
Task3) X-Coordinate



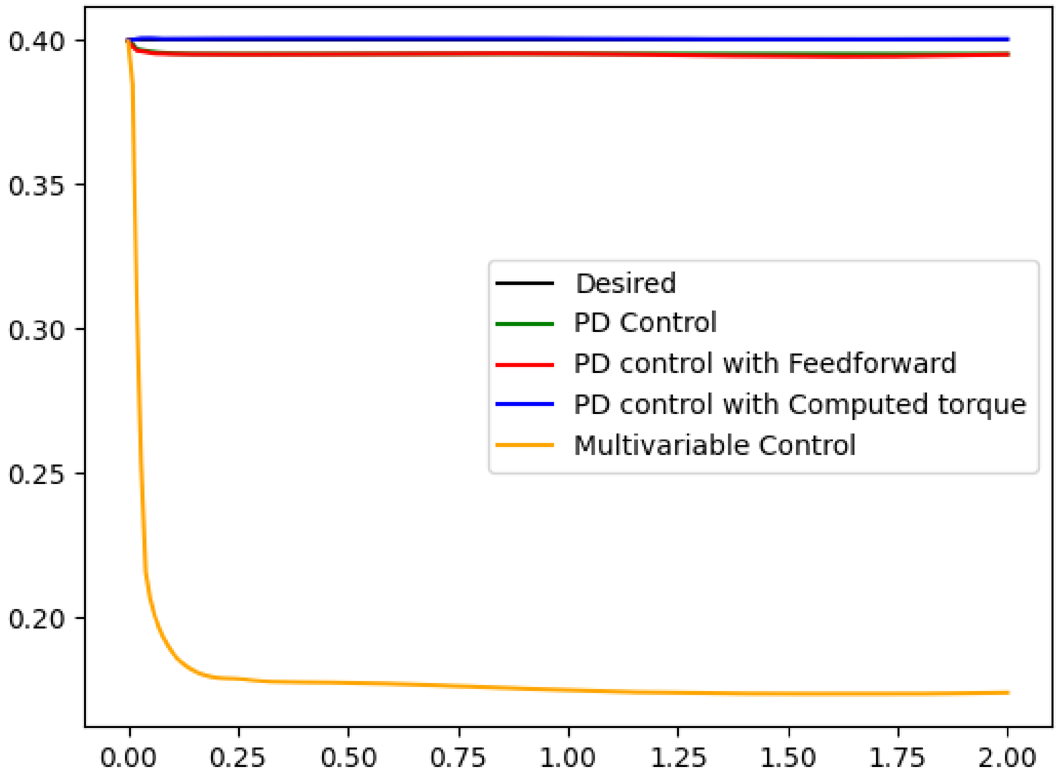
Y=Coordinate

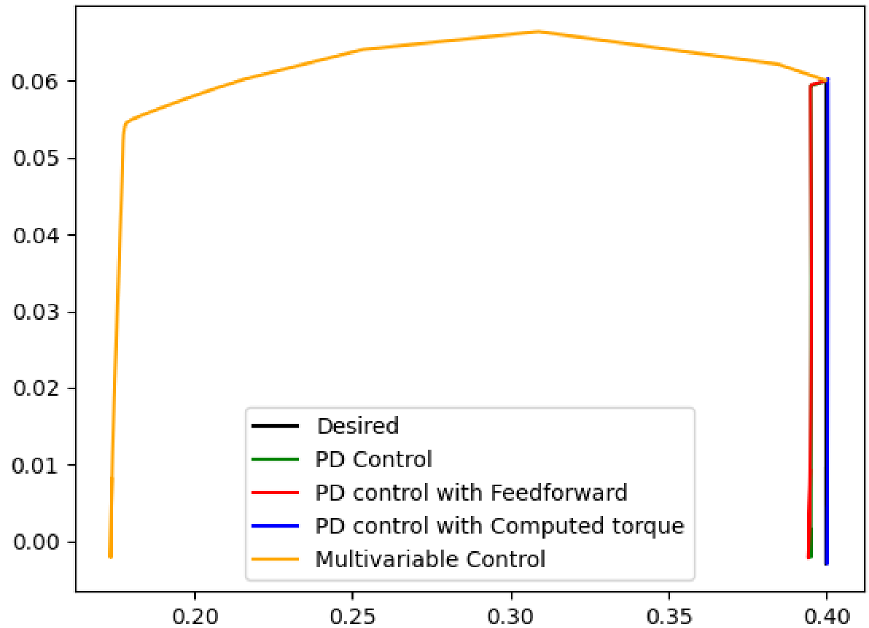


X-Y Coordinate

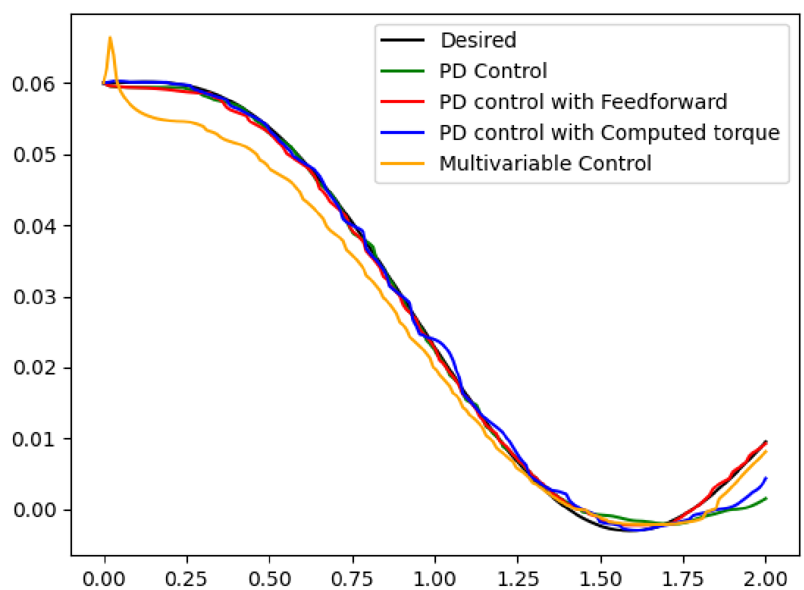


Task4) X-Coordinate



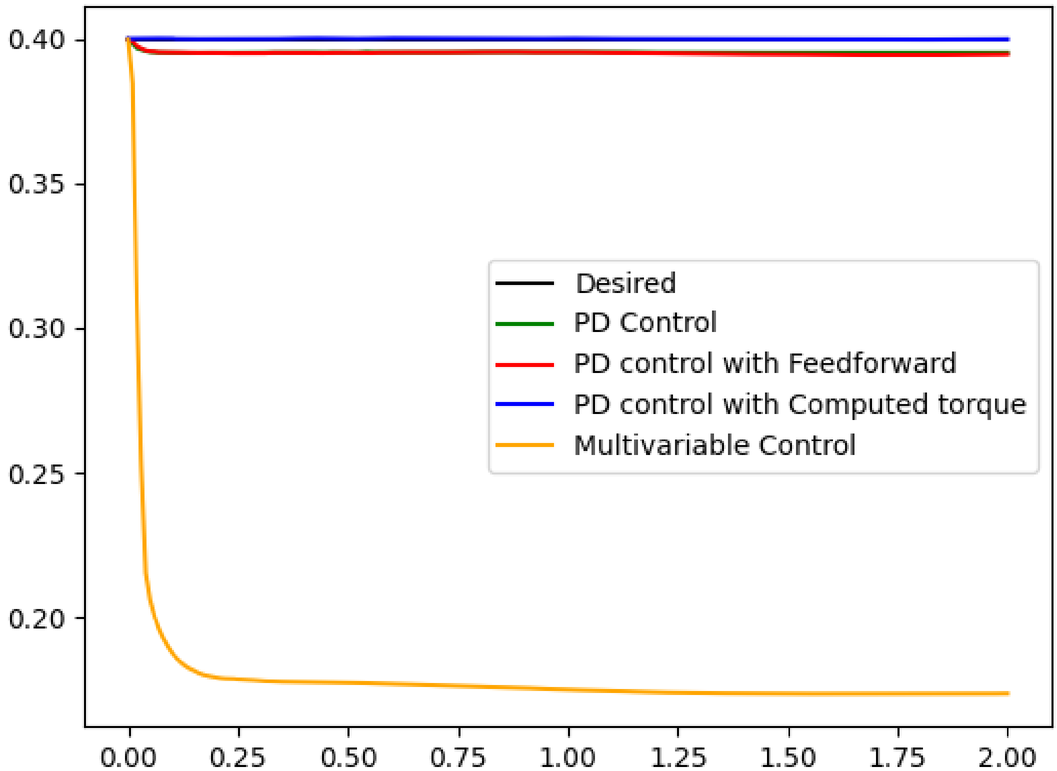


X-Y Coordinate

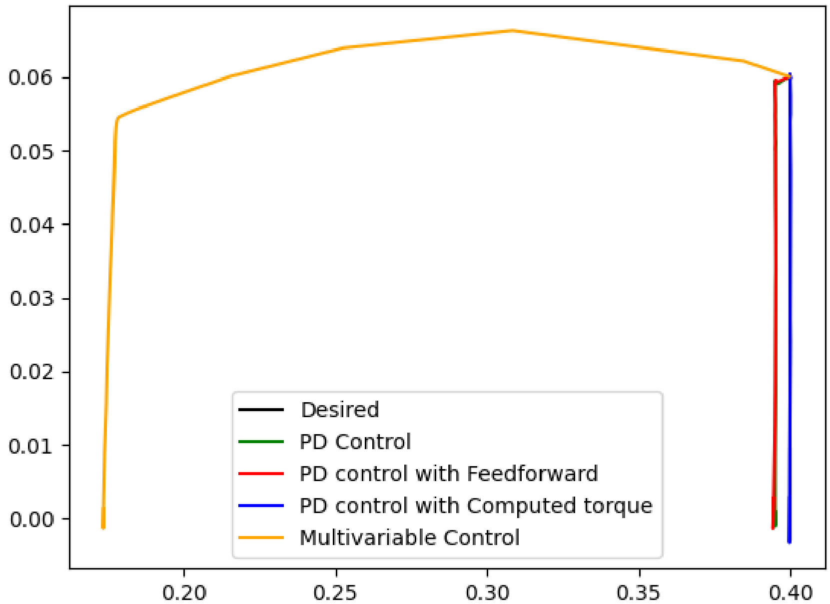


Y-Coordinate

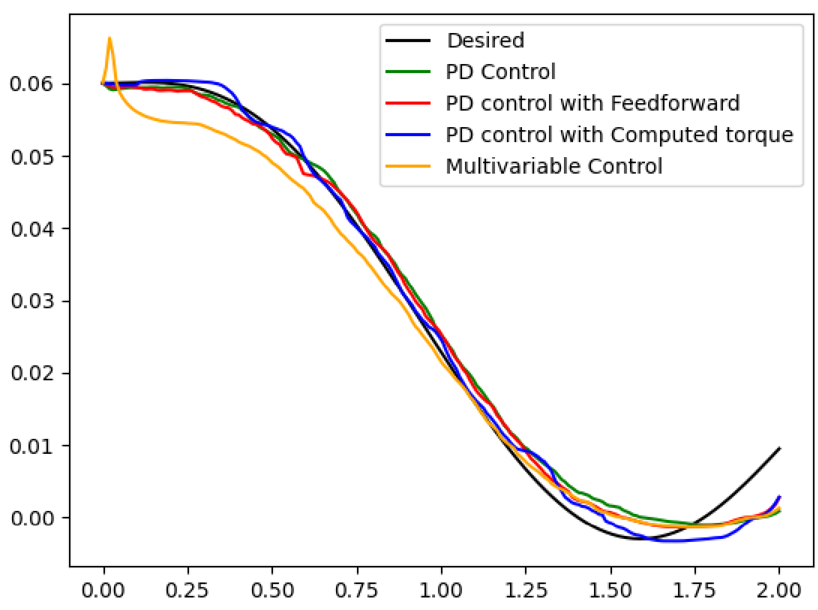
Task 5) X Coordinate



XY Coordinate



Y Coordinate



PREET SAAH
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Assignment 6.7

Using RUMA manipulator with link lengths and masses as:

$l_1 = 0.25$ $\qquad$ $m_1 = 1$

$l_2 = 0.25$ $\qquad$ $m_2 = 1$

$l_3 = 0.25$ $\qquad$ $m_3 = 1$

Q3.(a) PD Controller

Gains chosen are

$K_{P_1} = K_{P_2} = K_{P_3} = 100$

$K_{D_1} = K_{D_2} = K_{D_3} = 100$

The gains are

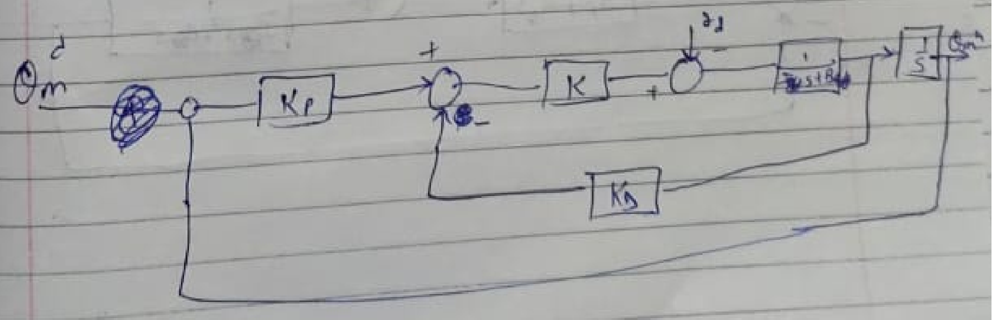
$$\omega_n = \sqrt{K_P} = 10$$

$$K_D = \frac{2\varepsilon \cdot 10 - 1}{1} \Rightarrow \varepsilon = 1$$

all other parameter are taken 1

$$J_{eff}\ddot{\theta}_{m_K} + B_{eff}\dot{\theta}_{m_K} = K V_K - r_K d_K$$

$$V_K = K_P(\theta_m^d - \theta_m) - K_d\dot{\theta}_m$$



θ_m^d = desired motor angle
θ_m = motor angle
$q = r\theta_m$
r = gear ratio (taken 1)

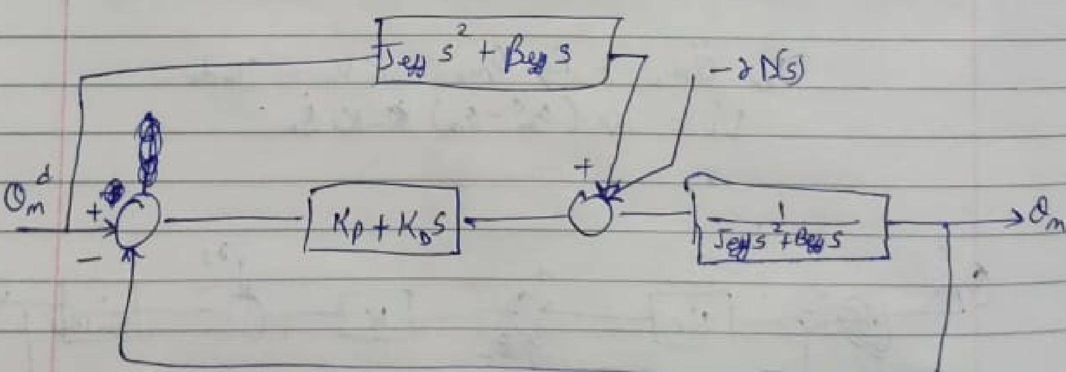
3(b)
Gain
$K_{P_1} = K_{P_2} = K_{P_3} = 100$
$K_{D_1} = K_{D_2} = K_{D_3} = 19$

Here the feed is given which is

$$f(t) = \frac{J_{eff}}{K}\ddot{\theta}_m^d + \frac{B_{eff}}{k}\dot{\theta}_m^d$$

where $J_{eff} = (J_m + d_{kk})$
and
$$B_{eff} = \left(B_m + \frac{K_b K_m}{R}\right)$$

Thus,
$$V(t) = f(t) + K_d(\dot{\theta}_m^d - \dot{\theta}_m) + K_p(\theta_m^d - \theta_m)$$



Q3(c) Gain

$$K_{P_1} = K_{P_2} = K_{P_3} = 100$$
$$K_{D_1} = K_{D_2} = K_{D_3} = 19$$

Here the feed given is

$$f(t) = \frac{J_{eff}}{K} \ddot{\theta}_m^d + B_{eff} \dot{\theta}_m^d$$

where $J_{eff} = (J_m + d_{kk})$

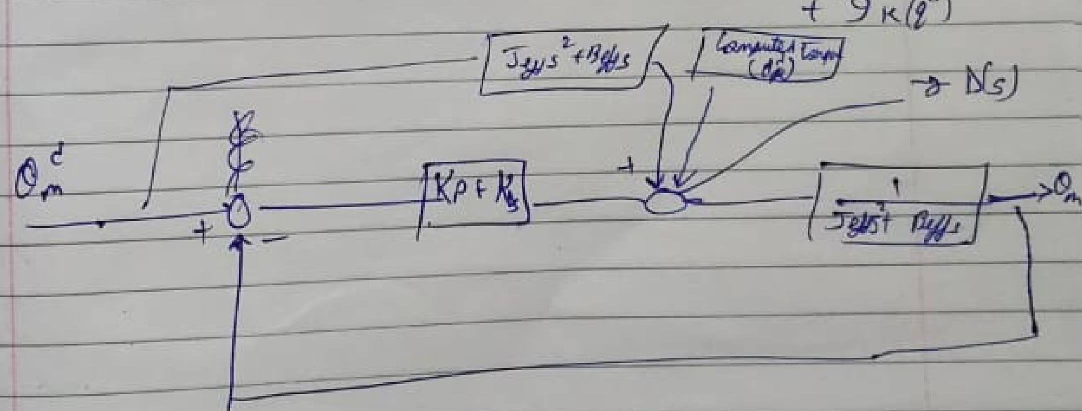
$$B_{eff} = \left(B_m + \frac{K_b K_m}{R}\right)$$

Thus

$$V(t) = f(t) + K_d(\dot{\theta}_m^d - \dot{\theta}_m) + K_p(\theta_m^d - \theta_m) + d^d(t)$$

where $d^d(t)$,

$$d_k^d(t) = \sum d_{kj}(q^d)\ddot{q}_j^d + \sum C_{ijk}(q^d)\dot{q}_i^d \dot{q}_j^d + g_k(q^d)$$



Q3(d) Gain

$K_{p_1} = K_{p_2} = K_{p_3} = 100$

$K_{D_1} = K_{D_2} = K_{D_3} = 10$

$$K_0 = 100 = \begin{bmatrix} \omega_1^2 & 0 & 0 \\ 0 & \omega_2^2 & 0 \\ 0 & 0 & \omega_3^2 \end{bmatrix}$$

$$\omega_1 = 10$$

$$K_1 = \begin{bmatrix} 2\omega_1 & 0 & 0 \\ 0 & 2\omega_2 & 0 \\ 0 & 0 & 2\omega_3 \end{bmatrix} = \begin{bmatrix} 20 & 0 & 0 \\ 0 & 20 & 0 \\ 0 & 0 & 20 \end{bmatrix}$$

$$a(t) = \ddot{q} + K_0 q + K_1 \dot{q}$$

$$v = a(t) + K_p (q^d - q) + K_D (\dot{q}^d - \dot{q})$$

I was not ablet to implement Task d in Q3, Q4 and Q5 properly as the results showed a big error

Task 7)
All the three controllers a,b and c had some amount of steady state error. The most efficient of them was the computed torque method as can bee observed in the results

The D controller, there was some error in the equation, thus it got difficult to implement.