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Assignment 6,7

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ME639-ITR

Q-1
Solution

Given end points A (0.4, 0.06, 0.1)
B (0.4, 0.01, 0.1)

APPLYING POLYNOMIAL TRAJECTORY METHOD

$$e(t) = b_0 + b_1 t + b_2 t^2 + b_3 t^3 + b_4 t^4 + b_5 t^5$$

$\hookrightarrow$ end effector position

Given boundary conditions
at $t = t_0$ & at $t = t_1$

$e(t) = e_0$ $\quad$ $e(t) = e_1$

velocity $\leftarrow v(t) = v_0$ $\quad$ $v(t) = v_1$

acceleratn $\leftarrow a(t) = a_0$ $\quad$ $a(t) = a_1$

So, at $t = t_0$, $e_0 = (0.4, 0.06, 0.1)$, $v_0 = 0$, $a_0 = 0$
and at $t = t_1$, $e_1 = (0.4, 0.01, 0.1)$, $v_1 = 0$, $a_1 = 0$

also $t_0 = 0$

$\Rightarrow$ $e_0 = b_0 = [0.4, 0.06 \ 0.1]$

$v_0 = b_1 = 0$

$a_0 = 2b_2 = 0$

let $t_f = 1$ sec
$\Rightarrow$ end effector reaches point B in 1 sec

$e_1 = b_0 + b_3 + b_4 + b_5 = [0.4 \ 0.01 \ 0.1]$

$v_1 = 3b_3 + 4b_4 + 5b_5 = 0$

$a_1 = 6b_3 + 12b_4 + 20b_5 = 0$

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Solving the equations we get

$b_0 = [0.4 \quad 0.06 \quad 0.1]$
$b_1 = 0$
$b_2 = 0$
$b_3 = [0 \quad -0.5 \quad 0]$
$b_4 = [0 \quad 0.75 \quad 0]$
$b_5 = [0 \quad -0.3 \quad 0]$

Q-3

Soln For a SCARA manipulator.

Equation of torques. $m_1, m_2, m_3 \rightarrow$ mass of links
$l_1, l_2, l_3 \rightarrow$ Length of links

$\rightarrow d_{11}\ddot{q}_1 + d_{12}\ddot{q}_2 - m_2 l_1 l_2 \sin q_2 \dot{q}_1 \dot{q}_2 - 2m_3 l_1 l_2 \sin q_2 \dot{q}_1 \dot{q}_2$
$- \dot{q}_2^2 (m_2 l_1 l_2 + 2m_3 l_1 l_2) \sin q_2 = \tau_1$

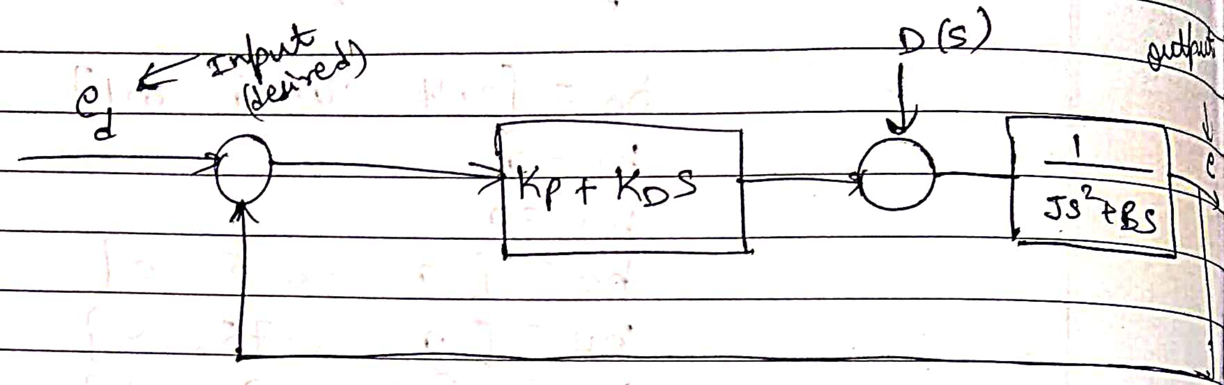
$\rightarrow d_{21}\ddot{q}_1 + d_{22}\ddot{q}_2 + d_{23}\ddot{q}_3 + \frac{1}{2}\dot{q}_1^2 (m_2 l_1 l_2 + 2m_3 l_1 l_2) \sin q_1 = \tau_2$

$\rightarrow d_{32}\ddot{q}_2 + d_{33}\ddot{q}_3 + 1 = \tau_3$

where $d_{11}, d_{12}, d_{32}, d_{32}$ are effective moment of Inertia about respective axis.

BLOCK DIAGRAMS

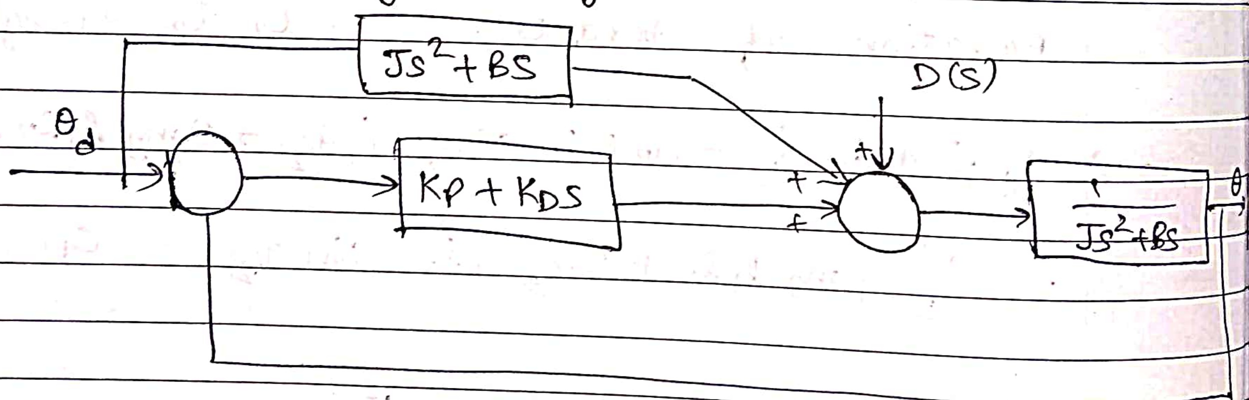
(a) PD Controller



Control equations

$$J_{eff}\,\ddot{e} + (B_{eff}+K_D)\,\dot{e} - K_p\,(e_d - e_s) - K_d\,\dot{e}_d = -d(t)$$

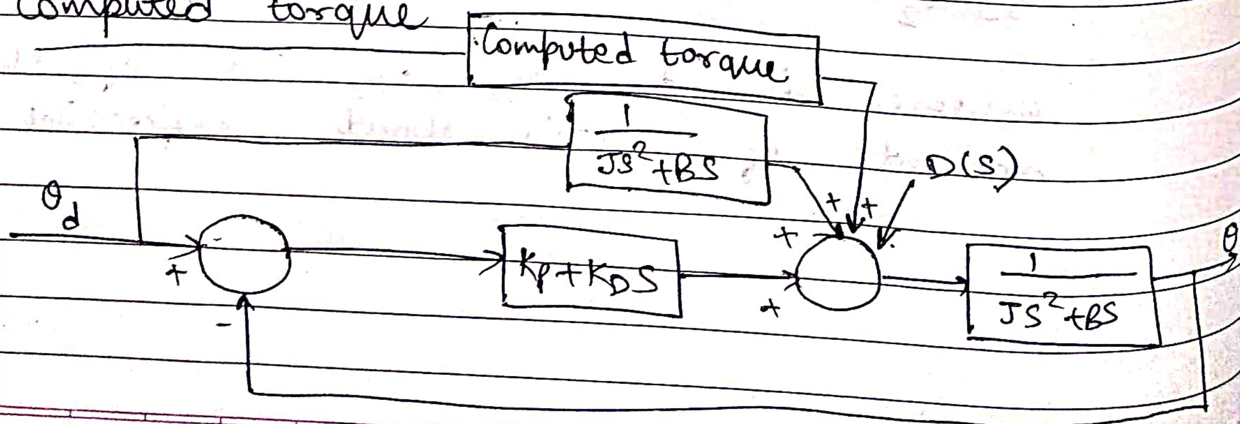
(b) PD with feed forward



Control equation

$$(\theta_d - \theta)(K_p + K_D s) + \theta_d\,(Js^2 + Bs) - D(s) = \theta\,(Js^2+Bs)$$

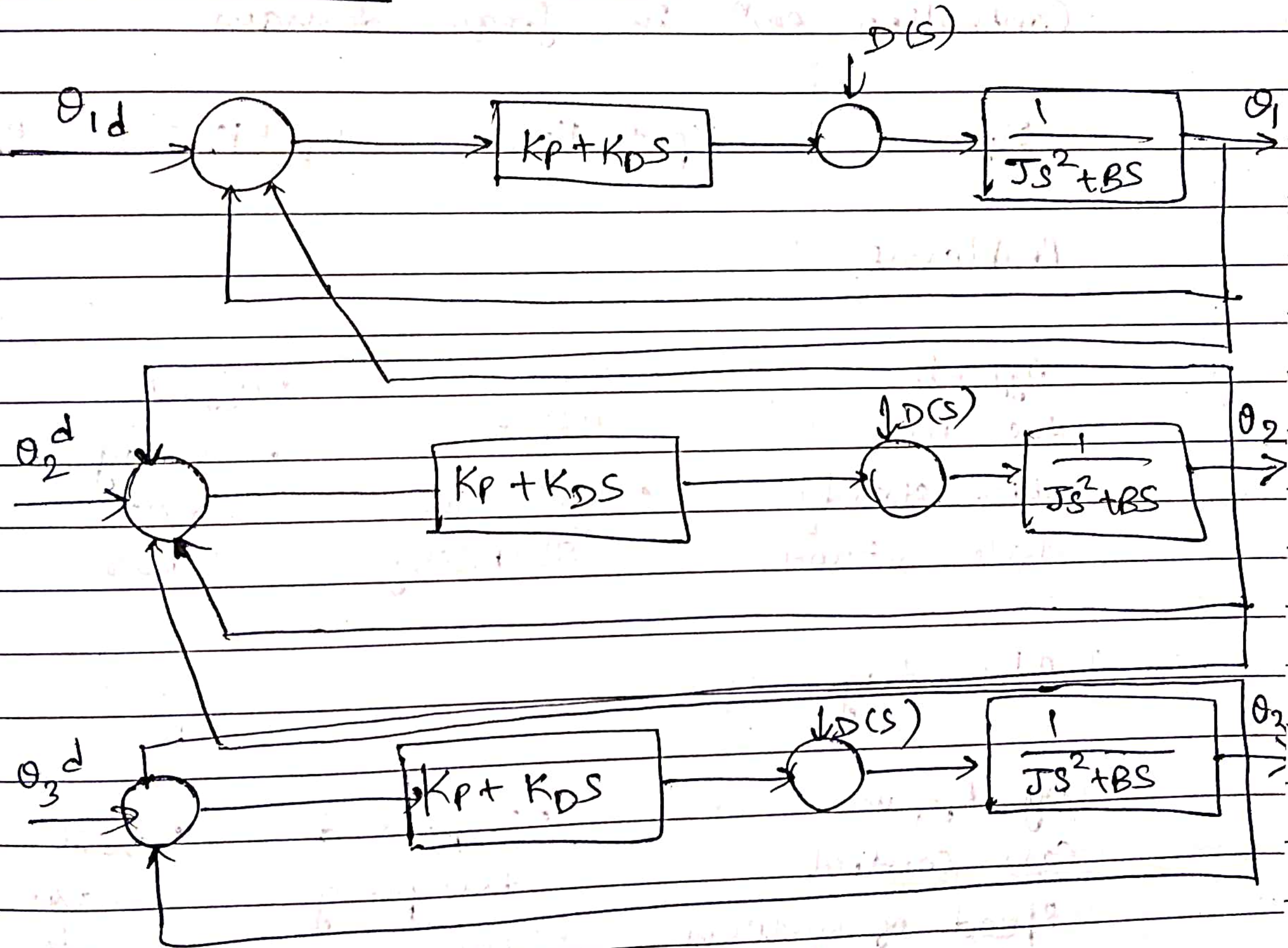
(c) PD with Computed torque



~~(D)~~ $J(\ddot{\theta}_d - \ddot{\theta}) + (B + K_D)(\dot{\theta}_d - \dot{\theta}) + K_p(\theta_d - \theta)$

$+ \tau_{\cancel{compe}\ \text{Computed}} = d(t)$

(D) <u>Multivariable control</u>



<u>~~Contxot~~ Control eqns</u>

(7)

	P	PI	PD	PID
Controller eq^n in time domain	K_p	$K_p + K_I \int dt$	$K_p + K_D \frac{d}{dt}$	$K_p + K_I \int dt + K_D \frac{d}{dt}$
Controller eq^n in freq. domain	K_p	$K_p + \frac{K_I}{S}$	$K_p + K_D S$	$K_p + \frac{K_I}{S} + K_D S$
Problems	Offset due to which steady state error	• Slow response • Issue in Stability	• offset • steady state error	K_p – Decreases rise time K_I – eliminate Steady State error K_D – decrease max. peak overshoot & settling time
Advantage	By K_p, we can control speed of system	• Improved damping • Zero offset • No steady state error	• ↓ese max. peak overshoot • reduce rise time, settling time • ↑ese Bandwidth.	