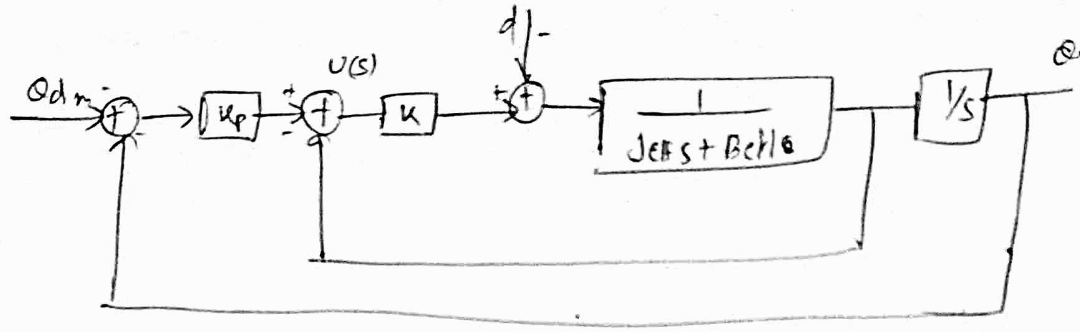
Q3

(a) PD control.



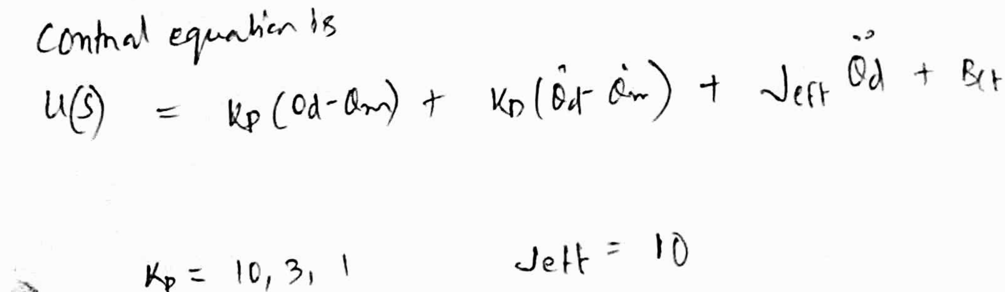
Control equation is

$$U(s) = K_P(\theta_d - \theta_m) + K_d(\dot{\theta}_d - \dot{\theta}_m)$$

$K_{P_i} = 10, 3, 1$

$K_{D_i} = 5, 1.25, 1$

(b) Same PD with feed forward model



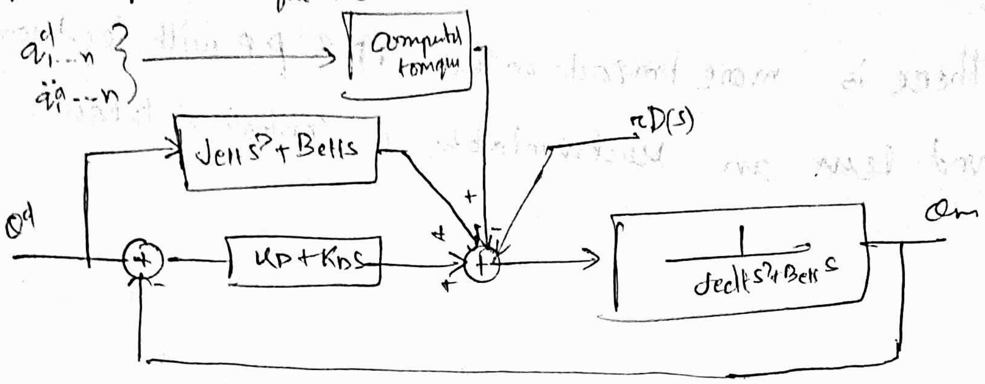
Control equation is

$$U(s) = K_P(\theta_d - \theta_m) + K_D(\dot{\theta}_d - \dot{\theta}_m) + J_{eff}\ddot{\theta}_d + B_{eff}\dot{\theta}_d$$

$K_P = 10, 3, 1$ $J_{eff} = 10$

$K_D = 5, 1.25, 1$ $B_{eff} = 10$

(c) Same PD control along with a feed forward disturbance cancellation using computed torque method.

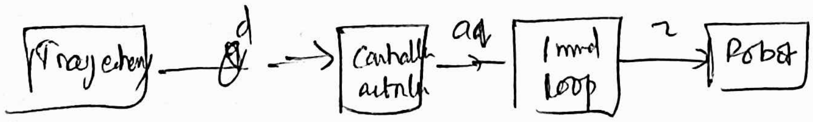


$$u(\theta) = K_d(\theta_d - \theta_m) + K_D(\dot{\theta}_d - \dot{\theta}_m) + J_{eff}\ddot{\theta}_d + B_{eff}\dot{\theta}_d$$

$$+ M(q)\ddot{q}_d + C(q, \dot{q}^d)\dot{q}_d + G(q)$$

Same as before $M(q^d)$, $C(q^d, \dot{q}^d)$, $G(q^d)$ is calculated

(d) Multi variable control



$$u = M(\theta)a_q + C(\theta, \dot{\theta})q_d + G(\theta)$$

$$a_q = \ddot{\theta}_d + K_e(e) + K_e(\dot{e})$$

$$e = \theta_d - \theta_m$$

Obervation! =>

Q 4, 5, 6,

there is more Impact on the PD, & PP with leed forward and less on Multivariable & Controlled to ram.