MECH 3140
Homework #9 Solutions

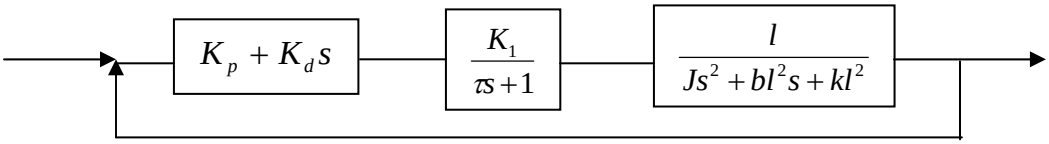
1

a) $v(t) = K_p e(t) + K_d \dot{e}(t)$

b) $\dfrac{F(s)}{V(s)} = \dfrac{K_1}{\tau s + 1}$

c) $\dfrac{\theta(s)}{F(s)} = \dfrac{l}{Js^2 + bl^2 s + kl^2}$

d)



f) $\dfrac{\theta(s)}{e(s)} = \dfrac{l(K_1)(K_p + K_d s)}{(Js^2 + bl^2 s + kl^2)(\tau s + 1)}$

g)

$$G = \frac{lK_1\sqrt{(K_p)^2 + (K_d\omega_o)^2}}{\sqrt{\left(kl^2 - J\omega_o^2 - \tau bl^2\omega_o^2\right)^2 + \left(\tau kl^2\omega_o + bl^2\omega_o - J\tau\omega_o^3\right)^2}}$$

$$\phi = \tan^{-1}\left(\frac{K_d\omega_o}{K_p}\right) - \tan^{-1}\left(\frac{\tau kl^2\omega_o + bl^2\omega_o - J\tau\omega_o^3}{kl^2 - J\omega_o^2 - \tau bl^2\omega_o^2}\right)$$

2

$k = m(2\pi)^2$

$b = m2(0.59)(2\pi)$

3.

$K_p = m(2\pi)^2$

$K_d = m2(0.59)(2\pi)$

4.

a)

$$\frac{V(s)}{d(s)} = \frac{1}{ms + b + K}$$

b) $$\frac{e(s)}{d(s)} = \frac{-1}{ms + b + K}$$

$$K > (100 - b)$$

c)

$$\frac{V(s)}{r(s)} = \frac{K}{ms + b + K}$$

Block Diagram Problems

B-10-1

$$\frac{C(s)}{R(s)} = \frac{G_1 + G_2}{1 + (G_1 + G_2)(G_3 + G_4)}$$

B-10-3

$$\frac{C(s)}{R(s)} = \frac{10(0.5s + 1)}{s(s + 2) + 10(0.5s + 1)} = \frac{5s + 10}{s^2 + 7s + 10}$$

B-10-4

$$\frac{C(s)}{R(s)} = \frac{10(s + 5)}{s(s + 1)(s + 2) + 10(s + 5)(0.5s + 1)}$$