- $K_d = 0.03$ $F = 100N$ $T = ?$

$K = 4kN/m$ $x = 16mm$

$$G(s) = \frac{X(s)}{F(s)} = \frac{1/K}{Ts+1}$$

$$F = Kx + K_d\, dx/dt \quad \ldots (1)$$

$$F = \frac{B\,dx}{dt} + Kx$$

Laplace Transform of (i)

$$F(s) = Kx + K_d s x$$

2.) $m = 0.5kg$ $\qquad \theta_1 = 20°C \qquad \theta = 119°C$

Specific Capacity = 346 $\qquad \theta_2 = 120°C$

$$\frac{\theta_1(s)}{\theta_2} = \frac{1}{Ts+1}$$

Show that $\theta = \theta_1 + (\theta_2 - \theta_1)(1 - e^{-t/T})$

$$\frac{\theta}{\theta_2} = \frac{1}{Ts+1}$$

~~Show that~~ $\theta = Ts\theta_2 + \theta_2$

$$\theta = \theta_2(Ts+1)$$

$$\theta_s = \frac{\theta_2}{Ts+1}$$

$$\theta(t) = \frac{1}{s(Ts+1)}$$ {Inverse Laplace Transform}

$$\theta(t) = \frac{1/T}{s(s+1/T)}$$

$$\theta(t) = 1 - e^{-t/T}$$

$$\theta(t) = \theta_1 + (\theta_2 - \theta_1)(1 - e^{-t/T})$$

$$119 = 20 + (120 - 20)(1 - e^{-t/T})$$

$$99 = 100(1 - e^{-t/T})$$

$$0.99 = (1 - e^{-t/T})$$

$$0.99 - 1 = -e^{-t/T}$$

$$-0.01 = -e^{-6/T}$$

$$\ln 0.01 = -6/T$$

$$T = 6/4.605$$

$$T = 1.302 \text{ mins.} \simeq 78.17s$$

Thermal Capacitance $C = mc = 0.5 \times 346 = 173 \, J/k$

$T = RC$	$R = \frac{78.17}{173} = 0.451 \, K/W$
$R = T/C$	

$$\overline{\;K_3\;} \qquad \overline{\;K_3\;}$$

$K_1, K_2 x, \omega, J, K_3, K_1 i$

Assuming no load torque

Torque $= K_1 i$

$= J\alpha + K_3 \omega$

$K_1 K_2 x(s) = Js(\omega) + K_3 \omega$

$(K_1 K_2 / K_3)\, x(s) = \omega \{ (J/K_3) s + 1 \}$

$$\frac{\omega}{K_m x} = \frac{1}{Ts+1}$$

$K_1 K_2\, x(s) = J d\omega/dt + K_3 \omega$

$K_1 K_2\, x(s) = \omega\, (Js + K_3)$

$K_m x(s) = \omega \{ Ts + 1 \}$

Scanned with CamScanner

$$-\frac{\theta_o(s)}{\theta_i} = \frac{1}{Ts+1}$$

$\theta_i(t) = ct$

$\theta_i(s) = c/s^2$

$$\theta_o(s) = \frac{\theta_i(s)}{(Ts+1)}$$

$$= \frac{c/s^2}{Ts+1}$$

$$= \frac{c}{s^2(Ts+1)}$$

$\theta_o(t) = c\{t - T(1-e^{-t/T})\}$

$\theta_2(t) = cT$

$G(s) = 1/(3s+1) \quad c=4,\ t=2$

After 2 sec.

$\theta_i = 4\times 2 = 8mm$

$\theta_o = 4(2-3(1-e^{-2/3}))$

$= 4(2-3(0.486))$

$= 4(2-1.459)$

$= 4(0.540)$

$= 2.161 mm$

$\theta_2 = 8 - 2.161$

$= 5.838 mm$

Steady state error is CT

$= 4\times 3$

$= 12mm$

$$= \frac{2}{0.2 \times 0 + 0.5}$$

$$= \frac{2}{0.5}$$

D.C gain = 4

$$\text{Time constant} = \frac{2/0.5}{(0.2/0.5)s + 1}$$

$$= \frac{4}{0.4s+1}$$

Time Constant = 0.4

ii.) $G(s) = \dfrac{0.2}{0.05s + 0.1}$

$\therefore \dfrac{\omega}{\theta}$

Gain =

Time C

$- X_o/X_i =$

T =

S =

θ_1

Am

Ph

Co

C =

- $\frac{\omega}{\theta}(s) = \frac{K_m}{T_m s + 2}$

$K_m = 15 s^{-1}$ and $T_m = 4 s$

$\therefore \frac{\omega}{\theta}(s) = \frac{15}{4s + 2}$

Gain $= 15/2 = K_m/B = 7.5 s^{-1}$

Time Constant $= 4/2 = T/B = 2$ seconds

- $X_o/X_i = 1/(T^2 s^2 + 2 \zeta T s + 1)$

$T = 0.4$ seconds

$\zeta = 0.2$

$\theta_1 = 6 \sin(\omega t)$ at 2.5 rad/s

Amplitude = ?

Phase Shift = ?

Constants C and D

$$C = \frac{(1 - \omega^2 T^2)}{\{(1-\omega^2 T^2) + (2\zeta \omega T)^2\}}$$

$$C = \frac{(1 - 2.5^2\ 0.4^2)}{\{(1 - 2.5^2\ 0.4^2) + (2 \times 0.2 \times 2.5 \times 0.4)^2\}}$$

$$C = \frac{0}{\{0 + (0.4)^2\}}$$

$$C = 0$$

$$D = \frac{2 \zeta T \omega}{\{(1 - T^2 \omega^2)^2 + (2\zeta \omega T)^2\}}$$

$$= \frac{2 \times 0.2 \times 0.4 \times 2.5}{\{(1 - 0.4^2\ 2.5^2)^2 + (2 \times 0.2 \times 2.5 \times 0.4)^2\}}$$

$$= \frac{0.4}{\{0 + (0.4)^2\}}$$

$$= \frac{0.4}{0.16}$$

$$= 2.5$$

$\phi = -\tan^{-1}(0/C) = -\tan^{-1}(\infty)$ therefore $\theta = 90^\circ$

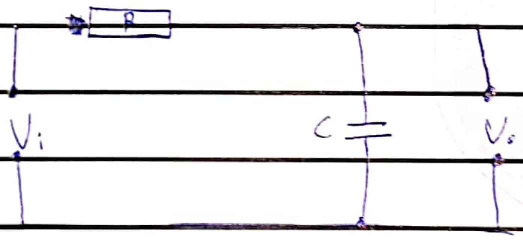
$$\left|\theta_o / \theta_i\right| = \sqrt{0^2 + C^2}$$

$$= \sqrt{2.5^2 + 0^2}$$

$$= 2.5$$

$$\theta = 6 \times 2.5$$

$$= 15^\circ$$



$$G(s) = \frac{V_o(s)}{V_i} = \frac{1}{Ts+1}$$ where