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EEE 324.

SYSTEM RESPONSE 1.

(1.) From the diagram

Spring $= K(x-0)$

Fdampers $\Rightarrow K\partial \frac{\delta(x-0)}{\delta t}$

$f(t) \Rightarrow f(t)$

$f(t) - k(x-0) - K\partial \frac{\delta(x-0)}{\delta t}$

$0 = f(t) - Kx - K\partial \frac{\delta x}{\delta t}$

Taking the laplace transform.

$\mathcal{L}\ f(s) = Kx(s) - K\partial s x(s) = 0.$

$f(s) = (K + K\partial s)\, x(s)$

$G(s) = \frac{x(s)}{f(s)} = \frac{1}{K + K\partial s}$

$\Rightarrow \frac{1/K}{1 + [K\partial/K]s}$

$\frac{x}{F(s)} = \frac{1/K}{(K\partial/K)s + 1} = \frac{1/K}{Ts + 1}$

$T = K\partial/K$

$= \frac{0.03}{4 \times 10^{3}}$

$T = 7.5 \times 10^{-6}$ seconds.

X_0 after T seconds.

$X_0 = f/K\,(1 - e^{-1})$

$= 100/4 \times 10^{-3}(1 - e^{-1})$

$= 0.0158m \simeq 0.016m$

2.) $E_2 = Mc\Delta\theta = mc(\theta_2 - \theta_1)$

$E_1 = mc(\theta_2 - \theta_1)$

θ = Now Temperature

$$G(s) = \frac{E_2}{E_1} = \frac{mc(\theta_2 - \theta_1)}{mc(\theta_2 - \theta_1)} = \frac{1}{Ts+1}$$

$$\frac{\theta - \theta_1}{\theta_2 - \theta_1} = \frac{1}{Ts+1}$$

$$\theta - \theta_1 = \frac{\theta_2 - \theta_1}{Ts+1}$$

let $\theta_2 - \theta_1(s) = K(t)$

$$(\theta - \theta_1)(s) = \frac{K(t)}{Ts+1}$$

then

$$(\theta - \theta_1(s) = \frac{K(t)(1/T)}{s + 1/T}$$

Laplace Transform. $D + K\delta t$.

$= K/s$.

$$(\theta - \theta_1)(s) = \frac{K(1/T)}{S(s + 1/T)}$$

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

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

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

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

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

$\ln 0.01 = -t/T$

$-4.605 = -t/T$

$T = t/4.605 = 1.302$ mins or 78.17 seconds.

Thermal Capacitance $C = mC = 0.5 \times 34.6 = 173\, J/K$

$T = RC$

$R = T/C$

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

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

$T = 1/K_S$ $\quad K_m = \frac{K_1 K_2}{K_S}$

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

Laplace Transform of the step input

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

$\frac{K_m x}{s}\left(\frac{1/T}{s+1/T}\right)$

$\omega(s) \Rightarrow K_m x\,(1 - e^{t/T})$

at $t = 0$ $K_m x\,(1 - e^{0}) =$ initial

at $t = T$ $K_m x\,(1 - e^{-1 \cdot t/T}) = 0.63\, K_m x.$

at $t = 4T =$ $K_m x\,(1 - e^{-4T/T})$

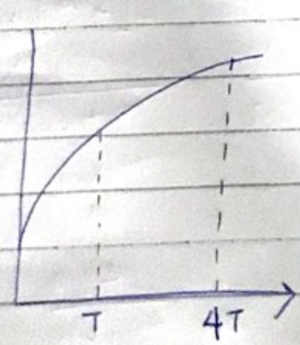
$= 0.981\, K_m x$

for $t = T$

$\Delta\% = (0.632 - 0) \times 100\% = 63.2\%$

$t = 4T$

$\Delta\% = (0.981 - 0) \times 100\% = 98.1\%.$



4.) $\frac{\theta_o(s)}{\theta_i} = \frac{1}{3s+1}$

$\theta_o(s) = \frac{\theta_i(s)}{3s+1}$

$\theta_o(s) = \frac{c}{s^2(3s+1)}$

$\theta_o(t) = \frac{c/3}{s^2(3s+1)}$

$\theta(t) = (ct - 3c(1 - e^{-t/3}))$

where $t + 5\omega$

$\theta_o(k) = (ct - 3c(1))$

$\theta_o(t) = (t - 3c)$

$\theta_t - \theta_2 - \theta_0 = ct - (ct - 3c) = 3c$

$T = 3 \quad c = 4mm/s.$

after 2 seconds.

$\theta_2 = 4mm \times 3 = 12mm$ at steady state

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

$= 2.16/mm.$

5 $\frac{2}{0.2+0.5} = \frac{2/0.5}{\frac{0.25}{0.5+1}}$

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

4 = DC gain
0.4 = Time constant.

(ii) $\frac{0.2}{0.05s+0.1} = \frac{0.2/0.1}{0.05s/(0.1+1)}$

$= 2/0.5s+1$

2 = DC gain
0.5 = Time constant

iii) $\frac{2}{3s+1}$

2 = DC gain

3 = Time constant

IV) $\frac{16}{8s+4} = \frac{16/4}{8/4s+1}$

$= \frac{4}{2s+1}$

4 = DC gain

2 = Time constant

6

$\frac{W(s)}{\theta} = \frac{Km}{Tms+2}$

$Km = 15s^{-1}$

$Tm = 4.$

$= \frac{15}{4s+2} = \frac{15/2}{4s/2+4/2}.$

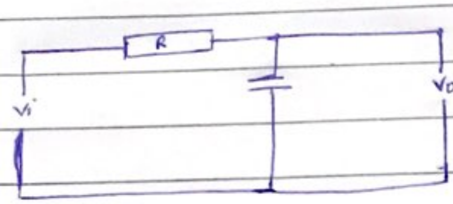
$= \frac{15/2}{4s/2+1} = \frac{7.5}{2s+1}$

D.C gain = $7.5ms^{-1}$

Time constant = 2 seconds.

4.) SYSTEM RESPONSE Q.

(i)



$T = RC$

$R \to 47\Omega \quad C = 20\mu F$

$V_i = 5\sin(2\pi t)$

$T = 47 \times 20 \times 10^{-6} = 9.4 \times 10^{-4}$

$\left[\frac{V_0}{V_I}\right](s) = \frac{1}{Ts+1}$

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

$G(w) = \frac{1}{9.4\times10^{-9}jw+1} \times \frac{9.4\times10^{-9}jw-1}{9.4\times10^{-9}jw-1}$

$G(w) = \frac{9.4\times10^{-9}jw-1}{(9.4\times10^{-9})^2w^2-1}$

5

$G(w) = \frac{-1}{(9.4\times10^{-9})w^2-1}$

where $w = 2000$ rad/s.

$\phi = \tan^{-1}\left(\frac{9.4\times10^{-1}(2000)^2-1}{1}\right)$

$\phi = -61.99$

$|G(jw)| = \frac{1}{\sqrt{(9.4\times10^{-9})^2w^2 + 1^2}}$

$= \frac{1}{\sqrt{(9.4\times10^{-9})(2000)^2+1^2}}$

$= 0.4696$

$V_0 = 5\times0.4696 = 2.35$

(2) $\frac{q_0}{x_1} = \frac{1}{\tau^2 s^2 + 2\delta\tau s + 1}$

$G(s) = \frac{1}{(1 + \tau^2 w^2) + 2\delta\tau s}$

$G(jw) = \frac{1}{(1 - \tau^2 w^2) + 2\delta\tau jw}$

$\delta = 0.2, \tau = 0.45, w = 2 \text{ srad/s}$

$G(jw) = \frac{1 - \tau^2 w^2 - 2\delta\tau jw}{(1 - \tau^2 w^2) + 4\delta^2\tau^2 w^2}$

$= \frac{1 - (0.4)^2 (2.5)^2 - 2(0.2)(0.4)(2.5)}{(1 - (0.4)^2 (2.5)^2) - 4(0.2)^2 (0.4)(2.5)^2}$

$G(jw) = \theta = 2.5$

$\tan^{-1}\left(\frac{2.5}{0}\right) = .$

$\tan^{-1} / \alpha = 90^\circ$

$|G jw| = \sqrt{0^2 + (2.5)^2}$

$= 2.5$

Amplitude $= 6 \times 2.5$

$= 15$