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17/ENG04/053
Elect/Elect.
Linear Systems.

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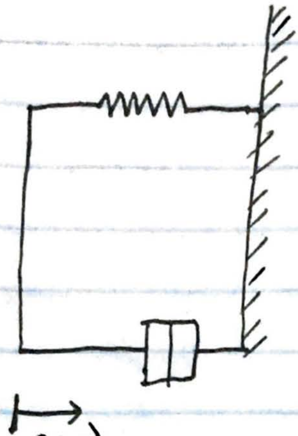


$x(t)$

Spring $\to K(x-\theta)$

Z(damper) $\to K_D \dfrac{d(x-\theta)}{dt}$

$f(t) \to f(t)$

From Newton's law, : $f(t) - K(x-\theta) - K_D \dfrac{d(x-\theta)}{dt} = 0$

$\to \quad 0 = f(t) - Kx - K_d \dfrac{dx}{dt}$

Laplace : $\mathcal{L}(f(s) - Kx(s) - K_D s x(s))$

$\Rightarrow f(s) - Kx(s) - K_D s\, x(s) = 0$

$f(s) = [K + K_d s] \times (s)$

$G(s) = \dfrac{X(s)}{F(s)} = \dfrac{1}{K + K_d s}$

$= \dfrac{1/K}{1 + [K_D/K]s}$

From $\dfrac{1/K}{Ts+1}$

$T = K_d/K = \dfrac{0.03}{4 \times 10^3}$

0.75×10^{-5}

$\varepsilon_2 = mc\,\Delta\theta = mc[\theta_2 - \theta_1]$

$\varepsilon_1 = mc[\theta_2 - \theta_1]$

$$G(s) = \frac{\varepsilon_2}{\varepsilon_1} = \frac{m_c[\theta_2 - \theta_1]}{m_c[\theta_2 - \theta]}$$

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

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

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

Let $\theta_2 - \theta_1 = K(t)$

$$\rightarrow (\theta_2 - \theta)(s) = \frac{K(t)}{Ts+1}$$

$$\Rightarrow [\theta_2 - \theta_1](s) = \frac{K(t)(1/T)}{s + 1/T}$$

Laplace of $K(t) = K/s$

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

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

(3)

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

$T = 1/K_S$ $\qquad K_m = K_1 K_2 / K_S$

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

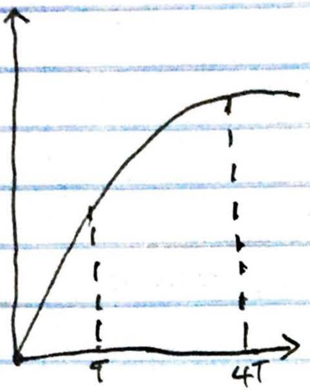
Laplace of step input

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

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

$$\omega(s) = K_m r(1 - e^{-t/T})$$

$t = 0$; $kmn(1-e^{t}) =$ Horizontal
$t = T$, $kmn(1-e^{-t/T}) = 0.63\,kmn$
$t = 4T$; $kmn(1-e) = 0.981\,kmn$
for $t = T$
$\Delta\% = (0.632) \times 100\% = 63.2\%$
$t = 4T$
$\Delta\% = (0.981 - 0) \times 100\% = 98\%$



(4) $\theta_i(t) = Ct$
$\theta_i(s) = C/s$
$$\frac{\theta_2(s)}{\theta_1} \neq \frac{1}{3s+1}$$
$$\theta_0(s) = \frac{\theta_i}{3s+1}$$
$$\rightarrow \theta_0(s) = \frac{C}{s^2} \div 3s+1$$
$$\frac{C}{s^2(3s+1)}$$
$$\theta_0 \quad \frac{1/3}{s^2(s+1/3)}$$
$\theta_0(t) = C[t - 3(1 - e^{-t/3})]$ — (1)

(a) t is close
$\theta_0(t) = C[t - 3(1)]$
$\theta_0(t) = (t - 3c)$
$\theta_1 = \theta_i - \theta_0 = Ct - [Ct - 3C] = Ct - Ct - 3C$
$= 3C$
$T = 3$, $C = 4$ mm/s

After 2 sec
$\theta_1 = 4 \times 2 = 8$ mm
$\theta_2 = 4 \times 3 = 12$ mm
$\therefore \theta_0(t) = C[t - 3(1 - e^{-t/3})]$

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

$= \frac{4}{0.4S+1}$ from $\frac{K}{TS+1}$

$\therefore$ 4 = DC gain & 0.4 = time constant.

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

$= \frac{2}{0.5S+1}$ from $\frac{K}{TS+1}$

$\Rightarrow$ 2 = DC gain , 0.5 = time constant

(iii) $\frac{2}{3S+1}$ $\Rightarrow$ from $\frac{K}{TS+1}$

$\Rightarrow$ 2 = DC gain , 3 = time constant

(iv) $\frac{16}{8S+4} = \frac{16/4}{\frac{8}{4}S+\frac{4}{4}}$

$\frac{4}{2S+1}$ from $\frac{K}{TS+1}$

$\Rightarrow$ 4 = DC gain , 2 = time constent.

(6)

$\frac{\omega}{\theta}(s) = \frac{Km}{TmS+2}$

$Km = 1.5^{S+1}$

$Tm = 4$

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

$\frac{\omega}{\theta}(s) = \frac{Km}{TmS+2}$

$Km = 1.5^{S+1}$, $Tm = 4$

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

$\therefore 7.5^{S+1}$ = DC gain , 2 = time constant