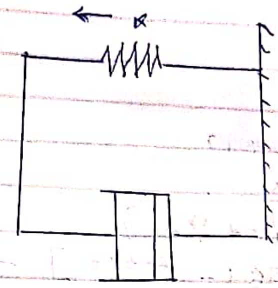
AROH IOCHUKWU .C.
17/ENG04/012
ELECT/ELECTRONICS ENGINEERING

Assignment One

1)



f_2 Spring $\Rightarrow K(x-0)$
f damper $\Rightarrow K_d \frac{d(x-0)}{dt}$

$f(t) \Rightarrow f(t)$
Newton's law $\Rightarrow f(t) - K(x-0) - K_d \frac{d(x-0)}{dt} = 0$

$0 = f(t) - Kx - K_d \frac{dx}{dt}$ laplace transform $\Rightarrow F(s) - Kx(s) - kd(s)$

$$f(s) = Kx(s) - kdsx(s)$$
$$F(s) = [K + Kds]X(s)$$
$$G(s) = \frac{X(s)}{f(s)} = \frac{1}{K + Kds} \Rightarrow \frac{1/K}{1 + [Kd/K]s}$$

Compare to $\frac{1/K}{Ts + 1}$

$$T = \frac{kd}{s} = \frac{0.03}{4 \times 10^3} = 0.75 \times 10^{-5} \text{ Seconds}$$
$$= 7.5 \times 10^{-6} s = 7.5 \mu s$$

4)

$\theta_i(t) = ct$

$\theta_i(s) = \frac{c}{s^2}$

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

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

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

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

$\theta_o(t) = c[t-3(1-e^{-t/3})] \quad -(i)$

where t is large

$\theta_o(t) = c[t-3(1)]$

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

$\theta_e = \theta_i - \theta_o = ct-(ct-3c) = 3c$

$T = 3 \qquad c = 4mm/s$

after 2 seconds

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

$\theta_e = c\times 3 = 4mm/s \times 3 = 12mm$

θ_o from (i)

$\theta_o = 4[2-3(1-e^{-2/3})] = 2.161mm$

5 $\frac{2}{0.25+0.5} = \frac{2/0.5}{0.025/0.5s+1}$

$\Rightarrow \frac{4}{0.45+1}$ Compare to $\frac{K}{Ts+1}$

$4 =$ D.C gain $\qquad 0.4 =$ Time constant

ii) $\frac{0.2}{0.05s+0.1} = \frac{0.2/0.1}{0.05s/0.1 + 0.1/0.1} = \frac{2}{0.5s+1}$

$2 =$ D.c gain $0.5 =$ Time Constant

iii) $\frac{2}{3s+1} \Rightarrow$ $2 =$ Dc gain
$3 =$ Time Constant

$\frac{16}{8s+4} \Rightarrow \frac{16/4}{8/4s+1} = \frac{4}{2s+1}$

$4 =$ D.c gain $2 =$ Time Constant

Q $\frac{\omega_{os}(s)}{\theta} = \frac{K_m}{T_m s + 2}$

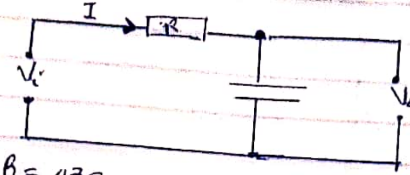
$K_m = 15s^{-1}$
$T_m = 4s$

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

Dc gain $= 7.5s^{-1}$ time Constant $= 2$

Assignment Two

1) An electric Circuit has a resistor and Capacitor has shown. Show that the transfer function is: $(V_o/V_i)(s) = 1/(Ts+1)$ where $T = RC$



Given that $R = 47\Omega$ and $C = 20\mu F$ determine the output voltage when the Output Voltage when the input is Sinusoidal such that $V_i = 5 \sin(2000t)$

Solution

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

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

$$G(j\omega) = \frac{1}{9.9\times10^{-9} j\omega + 1} \times \frac{9.9\times10^{-9} j\omega - 1}{9.9\times10^{-9} j\omega - 1}$$

$$G(j\omega) = \frac{9.9\times10^{-9} - 1}{(9.9\times10^{-9})\omega^2 - 1}$$

$$G(j\omega) = \frac{-1}{(9.9\times10^{-9})^2\omega^2 - 1} + \frac{9.9\times10^{-9} j\omega}{(9.9\times10^{-9})^2\omega^2 - 1}$$

$$\phi = \tan^{-1}\left[\frac{9.9\times10^{-9}(2000)}{9.9\times(10^{-4})\omega^2 - 1}\right]$$

$$\phi = -61.99°$$

$$|G(j\omega)| = \frac{1}{\sqrt{(9.4\times10^{-9})^2\omega^2 + 1^2}} \rightarrow \frac{1}{\sqrt{(9.4\times10^{-9})^2(2000)^2 + 1}} = 0.46$$

V_o = amplitude $= 5 \times 0.4696 = 2.348$

$\phi = 2000t - 62.99°$

$V_o = 2.348 \sin(2000t - 61.99°)$

$V_o = 2.35 \sin(2000t - 62°)$ V

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A standard second order system has the transfer function $X_o/X_i = 1/(T^2s^2+2\delta Ts+1)$. The time constant T is 0.4 seconds and the damping ratio $\delta = 0.2$. The input is varied harmonically as $\theta_i = 6\sin(\omega t)$

Solution

$$\frac{X_o}{X_i} = \frac{1}{T^2S^2+2\delta T+1} \qquad G(s) = \frac{1}{(1-T^2s^2)+2\delta Ts}$$

$$G(j\omega) = \frac{1}{(1-T\omega^2)+2\delta Tj\omega}$$

$\delta = 0.2 \qquad T = 0.4$ sec $\qquad \omega = 2.5$ rad/s

$$G(j\omega) = \frac{1-T^2\omega^2-2\delta Tj\omega}{(1-T^2\omega^2)+4\delta^2T^2\omega^2}$$

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

$$G(j\omega) = 0-2.5j$$

$$\phi = \tan^{-1}\left[\frac{2.5}{0}\right] \Rightarrow \tan^{-1}(\infty) = 90^\circ$$

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

Amplitude $= 6\times 2.5$
$= 15$