ME 104 HW SOLUTIONS DUE FRIDAY @ 5PM

PROB 1. 2.29 FROM TEXT SEE HW 1 SOLUTION

a) 0.025 mA

b) $I(t) = 0.0247\cos(\pi t - 0.156)$

PROB 2. 2.29 FROM TEXT, SET $V_s = 5 + 5\cos(\pi t)$ (HINT THIS IS A LINEAR CIRCUIT)

SIMILAR TO PROBLEM 2.29 a), b)

USE SUPERPOSITION SOLVE CKT FOR $V_s = 5$ V DC THEN $V_s = 5\cos(\pi t)$ and add solution $I(t)_{DC}$, $I(t)_{AC}$

$$\therefore \boxed{I(t) = 0.025\,mA + 0.0247\cos(\pi t - 8.94^\circ)}$$ or -0.156 rad

PROB 3. READ NOTES DO PROBLEM 1:

PROBLEM 1: FOLLOW THE DERIVATION IN EQUATIONS (1) THROUGH (5) IN THESE NOTES TO DERIVE THE IMPEDANCE OF A MASS, m.

I.E. FOR AN INDUCTOR:

$$V = L\frac{d}{dt}I \quad , \quad V \Rightarrow \hat{V}e^{j\omega t} \quad , \quad I \Rightarrow \hat{I}e^{j\omega t}$$

$$\downarrow$$

$$\hat{V}e^{j\omega t} = L\frac{d}{dt}\left(\hat{I}e^{j\omega t}\right)$$

$$\hat{V} = j\omega L\hat{I} \quad ; \quad \hat{V} = \hat{I}\hat{Z}$$

$$\hat{Z} = \frac{\hat{V}}{\hat{I}} = j\omega L$$

FOR A MASS m:

$$F = m\left(\frac{d}{dt}\right)\left(\frac{d}{dt}\right)x \rightarrow F = \hat{f}e^{j\omega t}, \quad x = \hat{x}e^{j\omega t}$$

$$\hat{f}e^{j\omega t} = m\left(\frac{d}{dt}\right)\left(\frac{d}{dt}\right)\left(\hat{x}e^{j\omega t}\right) = m\hat{x}\left(\frac{d}{dt}\right)\left(j\omega e^{j\omega t}\right)$$

$$\hat{f}\cancel{e^{j\omega t}} = m\hat{x}\left(j^2\omega^2\cancel{e^{j\omega t}}\right), \quad j^2 = -1$$

$$\hat{f} = m\hat{x}(-\omega^2) = -\omega^2 m\hat{x} \qquad \boxed{\frac{\hat{f}}{\hat{x}} = -\omega^2 m = \text{impedance}}$$

PROB 4 PROBLEM 4 IN THE "PHASOR ANALYSIS OF MECHANICAL SYSTEMS"

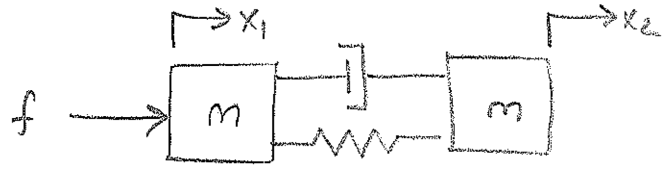
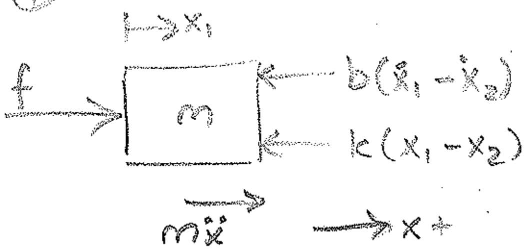


Fig. 3

a) solve for $\frac{\hat{x}_1}{\hat{f}}$

①

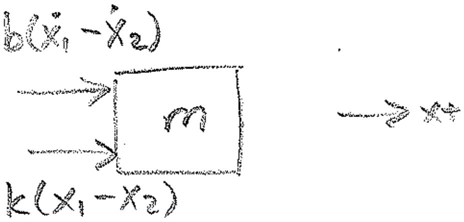


$$\sum F_x = f - b(\dot{x}_1-\dot{x}_2) - k(x_1-x_2) = m\ddot{x}$$

$$\mathcal{L}\left(f = m\ddot{x} + b(\dot{x}_1-\dot{x}_2) + k(x_1-x_2)\right)$$

$$(1) \qquad \hat{f} = ms^2\hat{x}_1 + bs(\hat{x}_1-\hat{x}_2) + k(\hat{x}_1-\hat{x}_2)$$

②



$$\sum F_x = b(\dot{x}_1-\dot{x}_2) + k(x_1-x_2) = m\ddot{x}_2$$

using Laplace $\mathcal{L}(\sum F_x)$

$$(2) \qquad 0 = -ms^2\hat{x}_2 + bs(\hat{x}_1-\hat{x}_2) + k(\hat{x}_1-\hat{x}_2)$$

$$ms^2\hat{x}_2 = bs\hat{x}_1 - bs\hat{x}_2 + k\hat{x}_1 - k\hat{x}_2$$

$$(ms^2+bs+k)\hat{x}_2 = (bs+k)x_1$$

$$\Rightarrow \quad \hat{x}_2 = \frac{bs+k}{ms^2+bs+k}\hat{x}_1 \qquad (3)$$

Then. $\hat{f} = ms^2\hat{x}_1 + bs\hat{x}_1 + k\hat{x}_1 - bs\hat{x}_2 - k\hat{x}_2$

$$\hat{f} = (ms^2+bs+k)\hat{x}_1 - (bs+k)\hat{x}_2$$

$$\hat{f} = (ms^2+bs+k)\hat{x}_1 - \frac{(bs+k)(bs+k)}{(ms^2+bs+k)}\hat{x}_1 \quad \text{using (3)}$$

$$\hat{f} = \frac{(ms^2+bs+k)^2-(bs+k)^2}{(ms^2+bs+k)}\hat{x}_1$$

↓

PROB 4 CONT.

$$\hat{f}(ms^2+bs+k) = \left[(ms^2+bs+k)^2 - (bs+k)^2\right]\hat{x}_1$$

$$\boxed{\frac{\hat{x}_1}{\hat{f}} = \frac{ms^2+bs+k}{(ms^2+bs+k)^2-(bs+k)^2}}$$

replace $s = j\omega$ for $\omega \to 0$, $\omega \to \infty$

$$\frac{\hat{x}}{\hat{f}} = \frac{1}{\text{impedance}}, \quad \text{impedance} = \frac{\hat{f}}{\hat{x}}$$

$$\frac{\hat{f}}{\hat{x}} = \frac{(m(j\omega)^2+b(j\omega)+k))^2-(b(j\omega)+k)^2}{m(j\omega)^2+b(j\omega)+k}$$

as $\omega \to 0$

$$\frac{\hat{f}}{\hat{x}} = \frac{k^2-k^2}{k} = 0$$

impedance goes to zero. DC force causes masses to be set in motion, thus attain a velocity, effective mass goes down.

as $\omega \to \infty$

$$\frac{\hat{f}}{\hat{x}} = \frac{\infty^4-\infty^2}{\infty^2+\infty} \to \infty$$

impedance goes to ∞
Alternating force cause impedance to go ∞ because of masses inertia

b) solve for $\frac{\hat{x}_2}{\hat{f}}$

$$\hat{f} = (ms^2+bs+k)\hat{x}_1 - (bs+k)\hat{x}_2$$

using (1), (2), (3)

$$\hat{x}_1 = \left(\frac{ms^2+bs+k}{bs+k}\right)\hat{x}_2$$

$$\hat{f} = \left(\frac{ms^2+bs+k}{1}\right)\left(\frac{ms^2+bs+k}{bs+k}\right)\hat{x}_2 - (bs+k)\hat{x}_2$$

$$\boxed{\frac{\hat{x}_2}{\hat{f}} = \frac{(bs+k)}{(ms^2+bs+k)^2-(bs+k)^2}}$$

PROBLEM 5: READ SECTION 2.7 IN TEXT AND ANSWER 2.33 IN TEXT.

2.33 IF STANDARD U.S. HOUSEHOLD VOLTAGE IS 120V RMS, WHAT IS THE PEAK VOLTAGE THAT WOULD BE MEASURED ON A DC COUPLED SCOPE?

$$V_{rms} = \frac{V_m}{\sqrt{2}} \quad , \quad V = V_m \sin(\omega t + \phi)$$

$$\text{PEAK} = V_m \quad , \quad \text{if } V_{rms} = 120V = \frac{V_m}{\sqrt{2}}$$

$$\boxed{V_m = 120\sqrt{2}\ V} \quad \text{OR} \quad \boxed{V_m = 169.7\ V}$$