

Chapter 3

Harmonically Excited Vibration

3.1 (a) $\delta = \frac{W}{k} = \frac{40}{4000} = 0.01 \text{ m}$
 (b) $\delta_{st} = \frac{F_0}{k} = \frac{40}{4000} = 0.01 \text{ m}$
 (c) $\omega_n = \sqrt{\frac{k}{m}} = \left(\frac{4000 \times 9.81}{40} \right)^{1/2} = 31.32 \text{ rad/sec}$
 $\omega = 2 \text{ Hz} = 12.566 \text{ rad/sec}$

$$X = \delta_{st} \left| \frac{1}{1 - \left(\frac{\omega}{\omega_n} \right)^2} \right| = 0.01 \left| \frac{1}{1 - \left(\frac{12.566}{31.32} \right)^2} \right| = 0.0115 \text{ m}$$

3.2 $T_1 = \frac{2\pi}{\omega_n - \omega} = \frac{2\pi}{12.566 - 12.566} = \infty \text{ sec}$

3.3 $k = 4000 \text{ N/m}$, $m = 10 \text{ kg}$, $F(t) = 400 \cos 10t \text{ N}$
 $F_0 = 400 \text{ N}$, $\omega = 10 \text{ rad/s}$
 $\omega_n = \sqrt{\frac{k}{m}} = 20 \text{ rad/s}$, $\frac{\omega^2}{\omega_n^2} = \frac{10}{40} = 0.25 < 1$
 Response is given by Eq. (3.9):

$$x(t) = \left(x_0 - \frac{F_0}{k - m\omega^2} \right) \cos \omega_n t + \left(\frac{\dot{x}_0}{\omega_n} \right) \sin \omega_n t + \frac{F_0}{k - m\omega^2} \cos \omega t \quad (E-1)$$

(a) $x_0 = 0.1$, $\dot{x}_0 = 0$:

Eq. (E-1) becomes

$$x(t) = \left\{ 0.1 - \frac{400}{4000 - 10(100)} \right\} \cos 20t + \frac{400}{4000 - 10(100)} \cos 10t$$

$$= -0.033333 \cos 20t + 0.133333 \cos 10t \quad (E-2)$$

(b) $x_0 = 0$, $\dot{x}_0 = 10$:

Eq. (E-1) becomes

$$x(t) = \left\{ 0 - \frac{400}{4000 - 10(100)} \right\} \cos 20t + \frac{10}{20} \sin 20t$$

$$+ \left\{ \frac{400}{4000 - 10(100)} \right\} \cos 10t$$

$$= -0.133333 \cos 20t + 0.5 \sin 20t + 0.133333 \cos 10t \quad (E-3)$$

Mechanical Vibrations Rao 4th Solutions Manual

Michael Rajnik



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