Solutions

2.1

- $\omega = 2\pi N/60 = 2\pi \times 1500/60 = 157.08$ rad/s.
- $F_0 = me\,\omega^2 = 0.002 \times 157.08^2 = \mathbf{49.3}$ N.
- $r = \omega/\omega_n = 157.08/44.72 = \mathbf{3.512}$.

2.2

- $2\zeta r = 0.398$; $1 - r^2 = -11.34$.
- $T = \sqrt{\dfrac{1 + (2\zeta r)^2}{(1 - r^2)^2 + (2\zeta r)^2}} = \sqrt{\dfrac{1 + 0.398^2}{11.34^2 + 0.398^2}} = \mathbf{0.0949}$.
- Floor force $= TF_0 = 0.0949 \times 49.3 = \mathbf{4.7}$ N.
- $X = (F_0/k)/\sqrt{(1 - r^2)^2 + (2\zeta r)^2} = (49.3/400\,000)/11.35 = \mathbf{10.9}$ µm.

3.1

- (a) At $r = 1$: $X = me/(2\zeta m) = 0.002/(2 \times 0.0567 \times 200) = \mathbf{88.2}$ µm, eight times the running amplitude.
- Run up quickly through about 7 Hz so the resonance has no time to build.
- (b) $f_{n,max} = \omega/(2\pi r) = 157.08/(2\pi \times 4.88) = \mathbf{5.12}$ Hz.
- (c) $k = m(2\pi f_n)^2 = 200 \times (2\pi \times 5)^2 = \mathbf{197.4}$ kN/m, $\mathbf{49.3}$ kN/m per mount.
- $\delta_{st} = mg/k = 1962/197\,400 = \mathbf{9.9}$ mm.
- $r = 25/5 = 5.0$, $T = 0.0479$, floor force $= \mathbf{2.36}$ N.
- (d) The machine sits lower and moves more under pipe loads or start-up, so it needs flexible connections and travel stops.

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