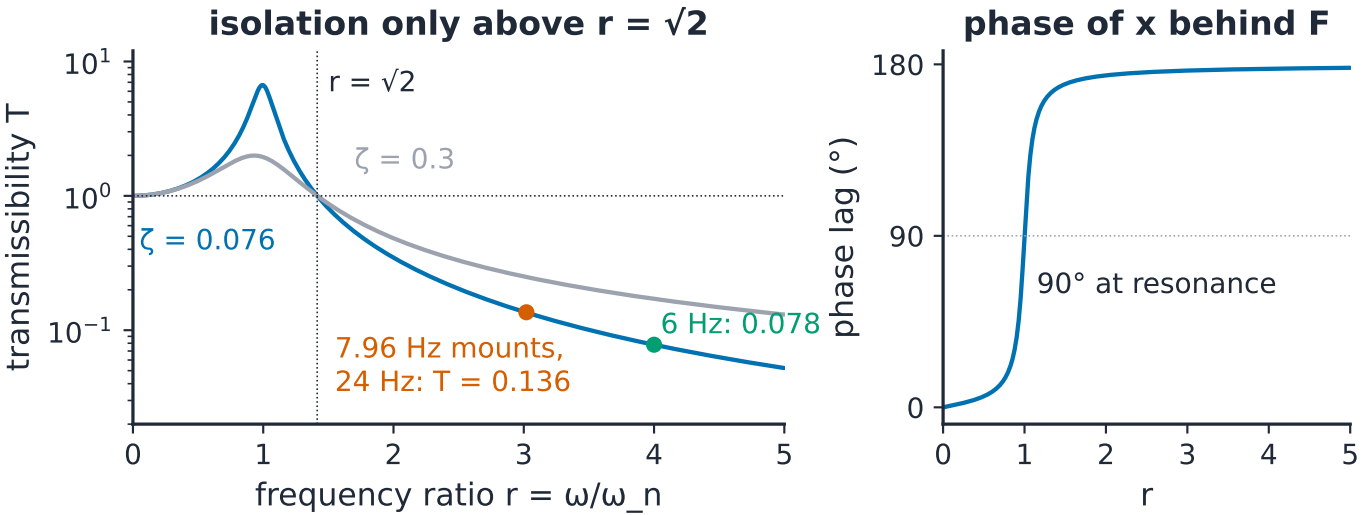
Exercise walk-through

11.5
Forced vibration

University Mechanical Engineering

Transmissibility and phase



24 Hz on 7.96 Hz mounts: $r = \mathbf{3.02}$, $T = \mathbf{0.136}$ - 3.7 N of the 27.3 N reaches the floor.

Designing for 90% isolation

1. **Target** $T \le 0.1$ at $\zeta = 0.076 \to r \ge 3.40 \to f_n \le 7.06$ Hz.
2. **Choose** $f_n = 6$ Hz $\to k = \mathbf{170.5}$ kN/m, four mounts of 42.6, deflection 6.9 mm.
3. **Result** $r = 4.0$, $T = \mathbf{0.078}$, 2.1 N to the floor.

Decision

Soft enough to isolate, stiff enough that the pipes do not pull the pump about.

Exercises 2.1·2.2

2.1 Find ω, the unbalance force F_0 (one decimal, N) and the frequency ratio r (three decimals). [3]

2.2 Find the transmissibility (four decimals), the force reaching the floor (one decimal, N) and the steady amplitude (one decimal, µm). [5]

Exercises 2.1·2.2

2.1 Find ω, the unbalance force F_0 (one decimal, N) and the frequency ratio r (three decimals). [3]

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 Find the transmissibility (four decimals), the force reaching the floor (one decimal, N) and the steady amplitude (one decimal, µm). [5]

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

Exercise 3.1

3.1 (a) Find the amplitude while the compressor passes through resonance during run-up (one decimal, µm) and say what the operator should do. (b) The site wants at most 5% transmissibility; for this ζ that needs $r \geq 4.88$. Find the highest allowed f_n (two decimals, Hz). (c) Choose $f_n = 5$ Hz: find the total and per-mount stiffness (one decimal, kN/m), the static deflection (one decimal, mm) and the floor force (two decimals, N). (d) Give one cost of the softer mounts. [9]

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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.