Solutions

2.1

- $k = 4k_{mount} = 4 \times 100 = 400$ kN/m; $\omega_n = \sqrt{k/m} = \sqrt{400\,000/200} = \mathbf{44.72}$ rad/s.
- $f_n = \omega_n / 2\pi = \mathbf{7.12}$ Hz.
- $\delta_{st} = mg/k = 200 \times 9.81 / 400\,000 = \mathbf{4.9}$ mm.

2.2

- $\delta = \ln(x_0/x_1) = \ln(4.0/2.8) = \mathbf{0.3567}$.
- $\zeta = \delta / \sqrt{4\pi^2 + \delta^2} = 0.3567 / 6.293 = \mathbf{0.0567}$.
- $c = 2\zeta\sqrt{km} = 2 \times 0.0567 \times \sqrt{400\,000 \times 200} = \mathbf{1014}$ N · s/m.
- $\omega_d = \omega_n \sqrt{1 - \zeta^2} = \mathbf{44.65}$ rad/s, almost unchanged.

3.1

- (a) $J_p = \pi d^4/32 = \pi \times 0.04^4/32 = 2.513 \times 10^{-7}$ m^4.
- $k_t = GJ_p/L = 80 \times 10^9 \times 2.513 \times 10^{-7} / 0.8 = \mathbf{25.1}$ kN · m/rad.
- (b) $\omega = \sqrt{k_t(J_1 + J_2)/(J_1 J_2)} = \sqrt{25\,133 \times 1.25 / 0.25} = \mathbf{354.5}$ rad/s.
- $f = 354.5 / 2\pi = \mathbf{56.4}$ Hz $= \mathbf{3385}$ rpm.
- (c) The discs swing in opposite directions with amplitudes in the ratio $J_2 : J_1$, so the node is $LJ_2/(J_1 + J_2) = 0.8 \times 0.25 / 1.25 = \mathbf{0.16}$ m from the flywheel.
- 1500 rpm is 44% of 3385 rpm, well clear of resonance; a 2nd-order excitation (3000 rpm) would come close.

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