HW9 #10.7, 10.32, 10.41, 10.53

(10.7)

10.7 The torques shown are exerted on pulleys *A*, *B*, and *C*. Knowing that both shafts are solid, determine the maximum shearing stress in (*a*) shaft *AB*, (*b*) shaft *BC*.

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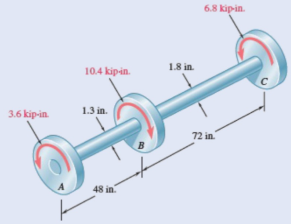

Fig. P10.7 and P10.8

a) AB: $T_{AB} = 3.6$ kip-in

$c_{AB} = \frac{1}{2} d = 0.65$ in

$$\tau_{max} = \frac{2 T_{AB}}{\pi c_{AB}^3}$$

$$= \frac{2(3.6 \times 10^3)}{\pi (0.65)^3} = 8.345 \text{ ksi}$$

b) BC: $T_{BC} = -3.6 + 10.4 = 6.8$ kip-in

$c_{AB} = \frac{1}{2} d_{BC} = 0.9$ in

$$\tau_{max} = \frac{2 T_{BC}}{\pi c_{BC}^3} = \frac{2(6.8 \times 10^3)}{\pi (0.9)^3} = 5.938 \text{ ksi}$$

10.32

10.32 The aluminum rod AB ($G = 27$ GPa) is bonded to the brass rod BD ($G = 39$ GPa).

Knowing that portion CD of the brass rod is hollow and has an inner diameter of 40 mm, determine the angle of twist at A.

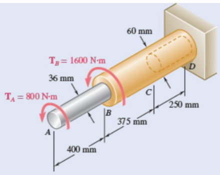

Fig. P10.32

$$\phi = \frac{TL}{JG}$$

$$J = \frac{\pi}{32}(d_o^4 - d_i^4)$$

$$\phi = \phi_{CD} + \phi_{BC} + \phi_{AB}$$

$$T_{BC} = T_{CD} = T_A + T_B$$

$$T_{AB} = T_A$$

$$\phi_{CD} = \frac{2400(0.25)}{\frac{\pi}{32}(0.06^4 - 0.04^4)(39\times10^9)} = 15.07\times10^{-3}\ \text{rad}$$

$$\frac{15.07\times10^{-3}\ \text{rad}}{2\pi}(360) = 0.8634\ \text{deg}$$

$$\phi_{BC} = \frac{2400(0.375)}{\frac{\pi}{32}(0.06^4)(39\times10^9)} = 18.14\times10^{-3}\ \text{rad}$$

$$\frac{18.14\times10^{-3}}{2\pi}(360) = 1.039\ \text{deg}$$

$$\phi_{AB} = \frac{800(0.4)}{\frac{\pi}{32}(0.036^4)(27\times10^9)} = 71.87\times10^{-3}\ \text{rad}$$

$$\frac{71.87\times10^{-3}}{2\pi}(360) = 4.118\ \text{deg}$$

$$0.8634 + 1.039 + 4.118 = 6.02\ \text{deg}$$

10.41

10.41 A torque of magnitude $T = 4$ kN·m is applied at end A of the composite shaft shown. Knowing that the modulus of rigidity is 77 GPa for the steel and 27 GPa for the aluminum, determine (a) the maximum shearing stress in the steel core, (b) the maximum shearing stress in the aluminum jacket, (c) the angle of twist at A.

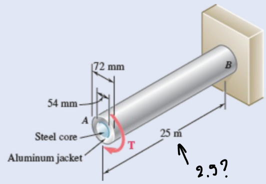

Fig. P10.41 and *P10.42*

a) $$T = \frac{JG\theta}{L} = \frac{\frac{\pi}{2}(0.0274)^4(77\times10^9)\theta}{L} = 64.28\times10^3\,\frac{\theta}{L}$$

$$T_{Al} = \frac{\frac{\pi}{2}(0.036^4 - 0.027^4)(27\times10^9)\theta}{L} = 48.70\times10^3\,\frac{\theta}{L}$$

$$T = T_s + T_{Al}$$

$$4000\ (64.28\times10^3\,\tfrac{\theta}{L}) + (48.70\times10^3\,\tfrac{\theta}{L})$$

$$\frac{\theta}{L} = \frac{4000}{(64.28+48.70)10^3} = 35.41\times10^{-3}\ \text{rad/m}$$

$$\tau_s = G_1 c_1 \frac{\theta}{L} = 77\times10^9(0.027)(35.406\times10^{-3}) = 73.6\ \text{MPa}$$

b) $$\tau_{Al} = G_2 c_2 \frac{\theta}{L} = 27\times10^9(0.036)(35.406\times10^{-3}) = 34.4\ \text{MPa}$$

c) $$\theta = L\times\frac{\theta}{L} = (2.5)(0.0354)\left(\frac{180}{\pi}\right) = 5.07^\circ$$

chose to use 2.5 instead of 25
bc answer matched back of book

10.53

10.53 A steel pipe of 12-in. outer diameter is fabricated from $\frac{1}{4}$-in.-thick plate by welding along a helix that forms an angle of 45° with a plane parallel to the axis of the pipe. Knowing that the maximum allowable tensile stress in the weld is 12 ksi, determine the largest torque that can be applied to the pipe.

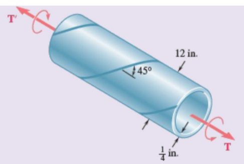

Fig. P10.53

$$\sigma_{45°}^{allow} = 12 \text{ ksi}$$

$$\sigma_{45} = \tau_{max}$$

$$c_2 = \frac{1}{2} d_o = \frac{1}{2}(12) = 6.00 \text{ in}$$

$$c_1 = c_2 - t = 6.00 - 0.25 = 5.75 \text{ in}$$

$$J = \frac{\pi}{2}(c_2^4 - c_1^4) = \frac{\pi}{2}\left[(6.00)^4 - (5.75)^4\right] = 318.67 \text{ in}$$

$$\tau_{max} = \frac{Tc}{J} \qquad T = \frac{\tau_{max} J}{c}$$

$$T = \frac{(12 \times 10^3)(318.67)}{6.00} = 637 \times 10^3 \text{ lb} \cdot \text{in}$$