10.15

The solid rod *AB* has a diameter d_{AB} = 60 mm and is made of a steel for which the allowable shearing tress is 85 MPa. The pipe *CD*, which has an outer diameter of 90 mm and a wall thickness of 6 mm, is made of an aluminum for which the allowable shearing stress is 54 MPa. Determine the largest torque **T** that can Be applied at *A*.

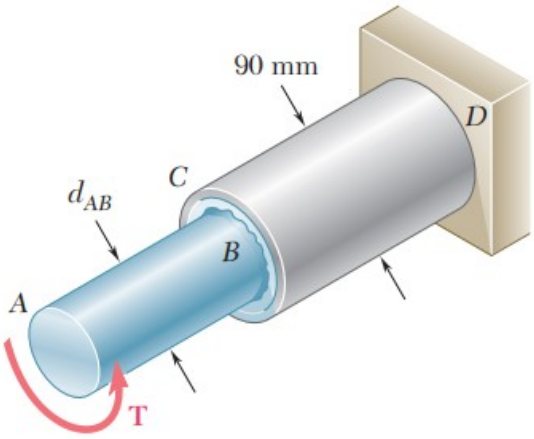


Fig. P10.15

$$J=\frac{1}{2}\pi\left(c_2^4-c_1^4\right)=\frac{1}{2}\pi\left(0.045^4-0.039^4\right)=2.81\times10^{-6}$$

$$\tau_{max}=54\times10^6=\frac{T_{max}c_2}{J}=\frac{T\times0.045}{2.81\times10^{-6}}$$

⇨ T_{max}= 3372 N.m

10.16

The allowable shearing stress is 50 MPa in the brass rod *AB* and 25 MPa in the aluminum rod *BC*. Knowing that a torque of magnitude *T* = 1250 N.m is applied at *A*, determine the required diameter of (*a*) rod *AB*, (*b*) rod *BC*.

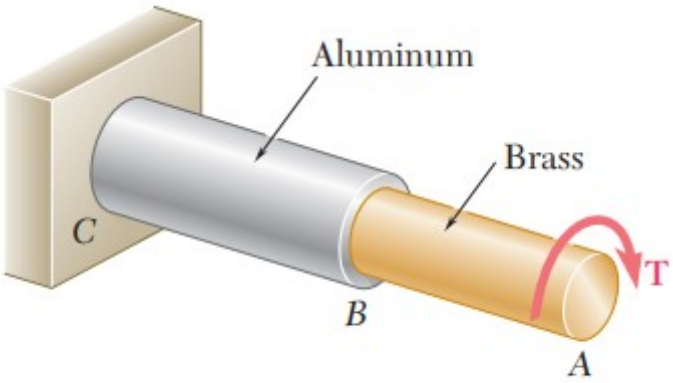


Fig. P10.16

a.

$$\tau_{max} = 50 \times 10^6 = \frac{T d_{AB}}{2J} = \frac{1250 \times d_{AB}}{\frac{1}{16}\pi d_{AB}^{\ 4}}$$

$$\leftrightarrow d_{AB}^3 = 1.2739 \times 10^{-4}$$

$$\leftrightarrow d_{AB} = 0.0503\, m$$

b.

$$J = \frac{1}{2}\pi\left(c_2^4 - c_1^4\right)$$

$$\tau_{max} = 25 \times 10^6 = \frac{T d_{BC}}{2J} = \frac{1250 \times d_{BC}}{\frac{1}{16}\pi d_{BC}^{\ 4}}$$

$$\leftrightarrow d_{BC}^3 = 2.5478 \times 10^{-4}$$

$$\leftrightarrow d_{BC} = 0.0634\, m$$

10.17

The solid shaft shown is formed of a brass for which the allowable shearing stress is 55 MPa. Neglecting the effect of stress concentrations, determine the smallest diameters d_{AB} and d_{BC} for which the allowable shearing stress is not exceeded.

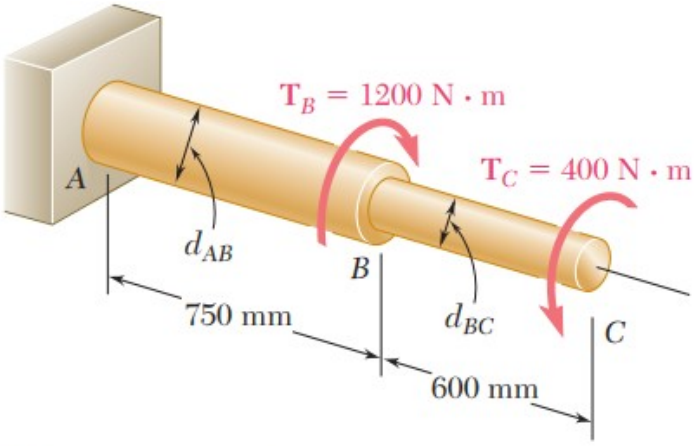


Fig. P10.17 and P10.18

Trục AB:

$T_{AB} = 1200 + 400 = 1600\, N.m$

$$\tau = 55 \times 10^6 = \frac{T\, d_{AB}}{2J} = \frac{1600 \times d_{AB}}{\frac{1}{16}\pi d_{AB}^{\,4}}$$

$$\leftrightarrow d_{AB}^3 = 7.4117 \times 10^{-5}$$

$$\leftrightarrow d_{AB} = 0.042\, m$$

Trục BC:

$T_{AB} = 400\, N.m$

$$\tau = 55 \times 10^6 = \frac{T\, d_{AB}}{2J} = \frac{400 \times d_{AB}}{\frac{1}{16}\pi d_{AB}^{\,4}}$$

$$\leftrightarrow d_{AB}^3 = 3.7058 \times 10^{-5}$$

$$\leftrightarrow d_{AB} = 0.0333\, m$$

10.18

Đề như bài 10.17 nhưng hướng của T_C bị đảo ngược

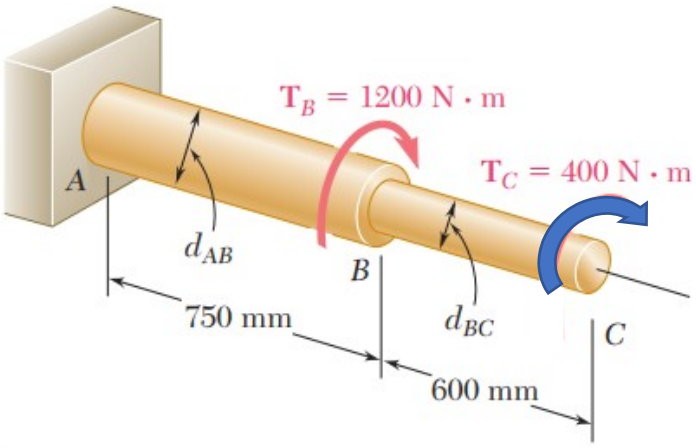


Fig. P10.17 and P10.18

Trục AB:

$T_{AB} = 1200 + 400 = 1600\, N.m$

$$\tau = 55 \times 10^6 = \frac{T\, d_{AB}}{2J} = \frac{1600 \times d_{AB}}{\frac{1}{16}\pi\, d_{AB}^{\,4}}$$

$$\leftrightarrow d_{AB}^3 = 1.4823 \times 10^{-5}$$

$$\leftrightarrow d_{AB} = 0.0529\, m$$

Trục BC:

$T_{AB} = 400\, N.m$

$$\tau = 55 \times 10^6 = \frac{T\, d_{AB}}{2J} = \frac{400 \times d_{AB}}{\frac{1}{16}\pi\, d_{AB}^{\,4}}$$

$$\leftrightarrow d_{AB}^3 = 3.7058 \times 10^{-5}$$

$$\leftrightarrow d_{AB} = 0.0333\, m$$

10.29

The torques shown are exerted on pulleys *A* and *B*. Knowing that the shafts are solid and made of steel (G = 77 GPa), determine the angle of twist between (*a*) *A* and *B*, (*b*) *A* and *C*.

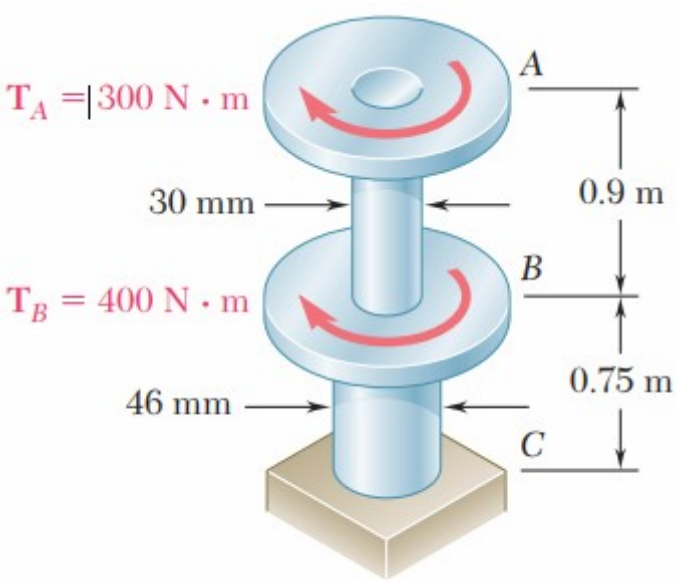


Fig. P10.29

$T_{AB} = 300$ N.m

$T_{BC} = 300 + 400 = 700$ N.m

$J_{AB} = 0.5\times0.015^4\times3.14 = 7.948\times10^{-8}$

$J_{BC} = 0.5\times0.023^4\times3.14 = 4.394\times10^{-7}$

$$\varnothing_{A/B}=\frac{T_{AB}L}{GJ_{AB}}=\frac{300\times0.9}{77\times10^9\times7.948\times10^{-8}}=0.044\,rad$$

$$\varnothing_{B/C}=\frac{T_{BC}L}{GJ_{BC}}=\frac{700\times0.75}{77\times10^9\times4.394\times10^{-7}}=0.016\,rad$$

$$\varnothing_{A/C}=\varnothing_{AB}+\varnothing_{BC}=0.044+0.016=0.06\,rad$$

10.30

The torques shown are exerted on pulleys *B*, *C*, and *D*. Knowing that the entire shaft is made of aluminum (G = 27 GPa), determine the angle of twist between (*a*) *C* and *B*, (*b*) *D* and *B*.

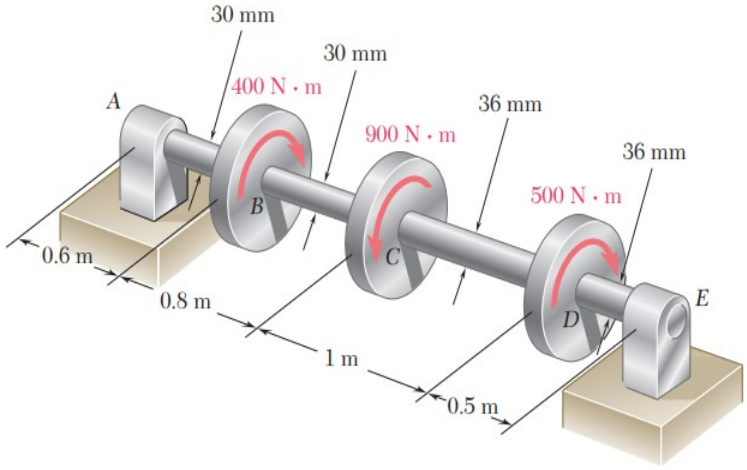


Fig. P10.30

T_{DC} = -500 N.m

T_{CB} = 900 – 500 = 400 N.m

$J_{CB} = 3.14\times0.015^4\times0.5 = 7.948\times10^{-8}$ m^4

$J_{DC} = 3.14\times0.018^4\times0.5 = 1.6483\times10^{-7}$ m^4

a. $\varnothing_{CB}=\dfrac{T_{CB}L}{GJ_{CB}}=\dfrac{400\times0.8}{27\times10^9\times7.948\times10^{-8}}=0.149\,rad=8.54°$

b. $\varnothing_{DC}=\dfrac{T_{DC}L}{GJ_{DC}}=\dfrac{-500\times1}{27\times10^9\times1.6483\times10^{-7}}=-0.112\,rad=-6.44°$

$\varnothing_{DB}=\varnothing_{DC}+\varnothing_{CB}=-6.44+8.54=2.1°$

10.32

The solid brass rod *AB* (G = 39 GPa) is bonded to the solid aluminum rod *BC* (G = 27 GPa). Determine the angle of twist (*a*) at *B*, (*b*) at *A*.

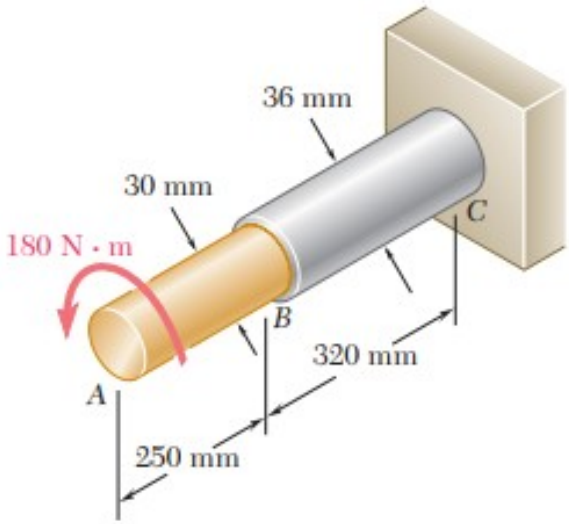


Fig. P10.32

$J_{BC} = 0.018^4 \times 3.14 \times 0.5 = 1.6483 \times 10^{-7}$

$J_{AB} = 0.015^4 \times 3.14 \times 0.5 = 7.948 \times 10^{-8}$

$T_{BC} = 180$ N.m

$T_{AB} = 180$ N.m

a.

$$\varnothing_B = \frac{T_{BC} L}{G_{BC} J_{BC}} = \frac{180 \times 0.32}{27 \times 10^9 \times 1.6483 \times 10^{-7}} = 0.01294\, rad = 0.741°$$

b.

$$\varnothing_A = \varnothing_B + \frac{T_{AB} L}{G_{AB} J_{AB}} = \left(0.01294 + \frac{180 \times 0.25}{39 \times 10^9 \times 7.948 \times 10^{-8}}\right) \times \frac{180}{3.14} = 1.573°$$

10.33

Two solid steel shafts (G=77 GPa) are connected by the gears shown. Knowing that the radius of gear B is r_B = 20 mm, determine the angle through which end A rotates when T_A = 75 N.m.

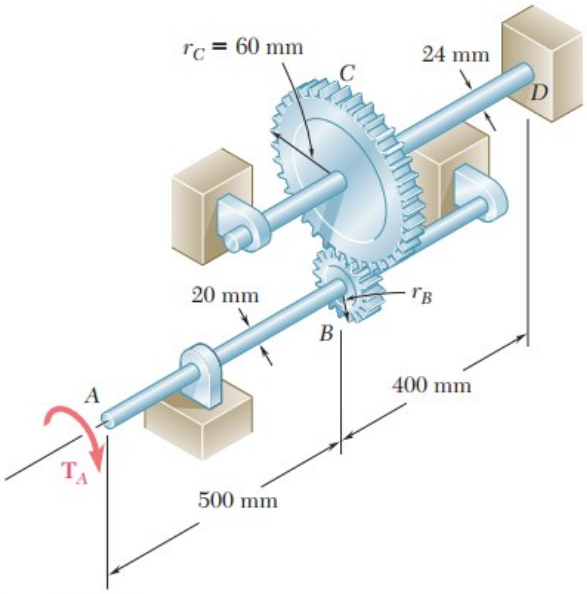


Fig. P10.33

$$\begin{cases} \sum B = 0 \leftrightarrow -T_A + F \times r_B = 0 \\ \sum C = 0 \leftrightarrow -T_{CD} + F \times r_C = 0 \end{cases} \leftrightarrow \begin{cases} -75 + F \times 0.02 = 0 \\ -T_{CD} + F \times 0.06 = 0 \end{cases} \leftrightarrow \begin{cases} F = 3750\, N \\ T_{CD} = 225\, N.m \end{cases}$$

$J_{CD} = 0.012^4 \times 3.14 \times 0.5 = 3.25 \times 10^{-8}$ m^4

$J_{AB} = 0.01^4 \times 3.14 \times 0.5 = 1.57 \times 10^{-8}$ m^4

$$\varnothing_C = \frac{T_{CD} \times L_{CD}}{G \times J_{CD}} = \frac{22\,5 \times 0.4}{77 \times 10^9 \times 3.25 \times 10^{-8}} = 0.0\,3596\,rad$$

$$r_c \times \varnothing_C = r_B \times \varnothing_B \leftrightarrow 0.0\,6 \times 0.0\,3596 = 0.02 \times \varnothing_B \leftrightarrow \varnothing_B = 0.10788\,rad$$

$$\varnothing_A = \varnothing_B + \frac{T_{AB} \times L_{AB}}{G \times J_{AB}} = 0.10788 + \frac{75 \times 0.5}{77 \times 10^9 \times 1.57 \times 10^{-8}} = 0.1389\,rad = 7.95\,°$$

10.55

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*.

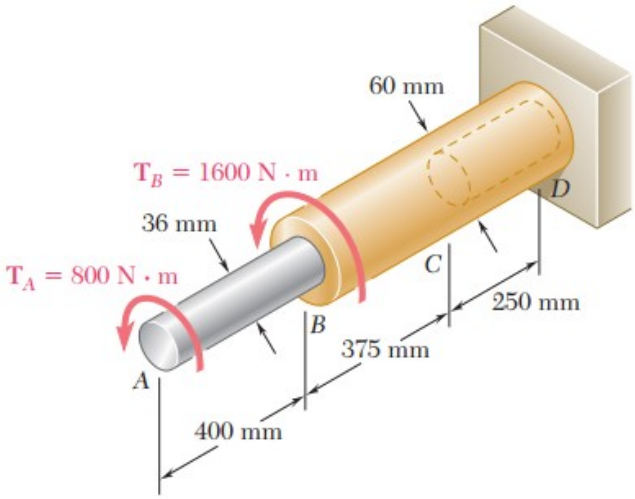


Fig. P10.55

T_{AB} = 800 N.m

T_{BC} = 800 + 1600 = 2400 N.m

T_{CD} = 2400 N.m

$J_{AB} = 0.018^4 \times 0.5 \times 3.14 = 1.648 \times 10^{-7}\ m^4$

$J_{BC} = 0.03^4 \times 3.14 \times 0.5 = 1.272 \times 10^{-6}\ m^4$

$J_{CD} = (0.03^4 - 0.02^4) \times 3.14 \times 0.5 = 1.021 \times 10^{-6}\ m^4$

$$\varnothing_A = \frac{\sum T_i \times L_i}{\sum G_i \times J_i}$$

$$¿\left(\frac{800 \times 0.4}{27 \times 10^9 \times 1.648 \times 10^{-7}} + \frac{2400 \times 0.375}{39 \times 10^9 \times 1.272 \times 10^{-6}} + \frac{2400 \times 0.25}{39 \times 10^9 \times 1.021 \times 10^{-6}} \right) \times \frac{180}{\pi}$$

$= 6.02^0$