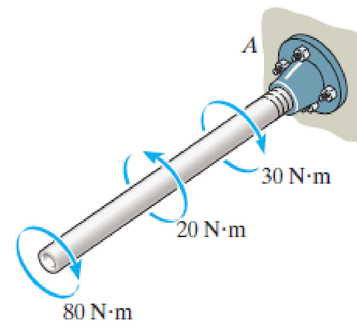
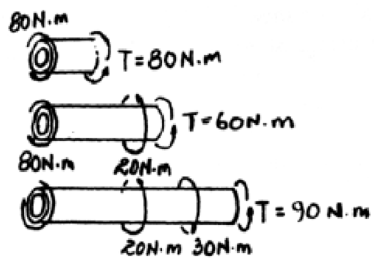
5–5. The copper pipe has an outer diameter of 40 mm and an inner diameter of 37 mm. If it is tightly secured to the wall at A and three torques are applied to it as shown, determine the absolute maximum shear stress developed in the pipe.

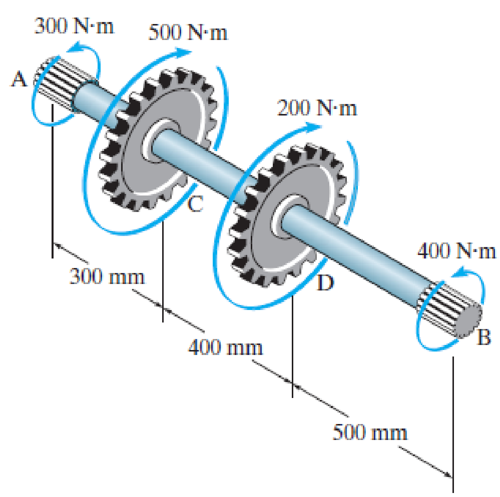


$$\tau_{max} = \frac{T_{max}\,c}{J} = \frac{90(0.02)}{\frac{\pi}{2}(0.02^4 - 0.0185^4)}$$

$$= 26.7 \text{ MPa}$$ **Ans..**



***5–8.** The solid 30-mm-diameter shaft is used to transmit the torques applied to the gears. Determine the absolute maximum shear stress on the shaft.

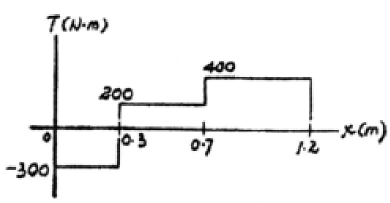


Internal Torque: As shown on torque diagram.

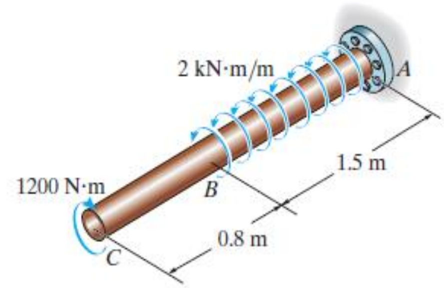
Maximum Shear Stress: From the torque diagram $T_{max} = 400 \text{ N} \cdot \text{m}$. Then, applying torsion Formula.

$$\tau^{abs}_{max} = \frac{T_{max}\,c}{J}$$

$$= \frac{400(0.015)}{\frac{\pi}{2}(0.015^4)} = 75.5 \text{ MPa}$$ **Ans.**



5–22. The solid shaft is subjected to the distributed and concentrated torsional loadings shown. Determine the required diameter d of the shaft to the nearest mm if the allowable shear stress for the material is $\tau_{allow} = 50$ MPa.



The internal torque for segment BC is constant $T_{BC} = 1200$ N · m, Fig. a. However, the internal torque for segment AB varies with x, Fig. b.

$$T_{AB} - 2000x + 1200 = 0 \quad T_{AB} = (2000x - 1200) \text{ N} \cdot \text{m}$$

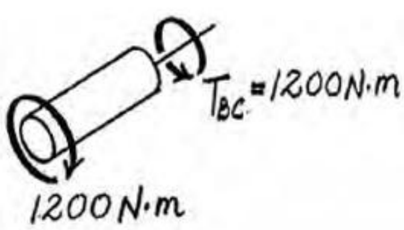
For segment AB, the maximum internal torque occurs at fixed support A where $x = 1.5$ m. Thus,

$$\left(T_{AB}\right)_{max} = 2000(1.5) - 1200 = 1800 \text{ N} \cdot \text{m}$$

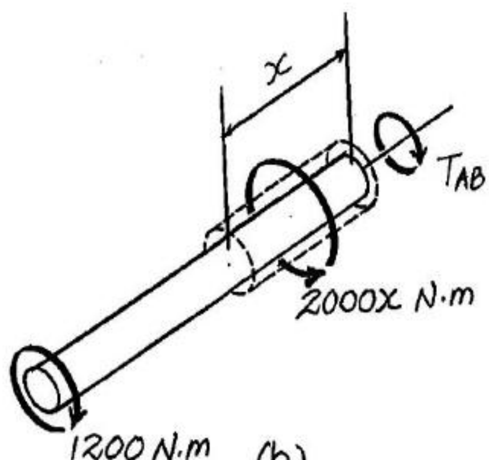
Since $\left(T_{AB}\right)_{max} > T_{BC}$, the critical cross-section is at A. The polar moment of inertia of the rod is $J = \frac{\pi}{2}\left(\frac{d}{2}\right)^4 = \frac{\pi d^4}{32}$. Thus,

$$\tau_{allow} = \frac{Tc}{J}; \qquad 50(10^6) = \frac{1800(d/2)}{\pi d^4/32}$$

$$d = 0.05681 \text{ m} = 56.81 \text{ mm} = 57 \text{ mm} \qquad \textbf{Ans.}$$



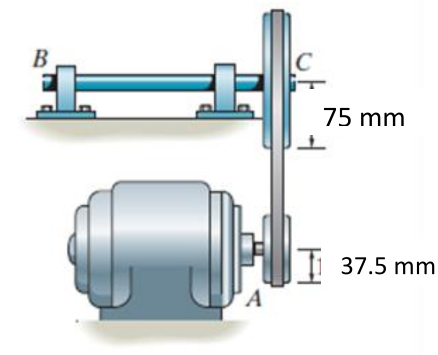
(a)



(b)

5-46. The motor delivers 12 KW to the pulley at A while turning at a constant rate of 1800 rpm. Determine to the nearest multiples of 5 mm the smallest diameter of shaft BC if the allowable shear stress for steel τ_{all}=84 MPa. The belt does not slip on the pulley.

Solution:-



The angular velocity of shaft BC can be determined using the pulley ratio that is

$$\omega_{BC} = \left(\frac{r_A}{r_C}\right)\omega_A = \frac{37.5}{75}\left(1800\,\frac{\text{rev}}{\text{min}}\right)\left(\frac{2\pi\text{ rad}}{1\text{ rev}}\right)\left(\frac{1\text{ min}}{60\text{ s}}\right) = 30\pi\text{ rad/s}$$

The power is

$P =$ 12000 W = 12000 N.m/s

Thus,

$$T = \frac{P}{\omega} = \frac{12000}{30\,\pi} = 127.33\ N.m$$

The polar moment of inertia of the shaft is $J = \frac{\pi}{2}\left(\frac{d}{2}\right)^4 = \frac{\pi d^4}{32}$. Thus,

$$\tau_{allow} = \frac{Tc}{J}; \qquad 84 = \frac{127.33 * 1000 * (\frac{d}{2})}{\pi(\frac{d^4}{32})}$$

$$\boldsymbol{d = 19.8\ mm}$$ **Ans.**