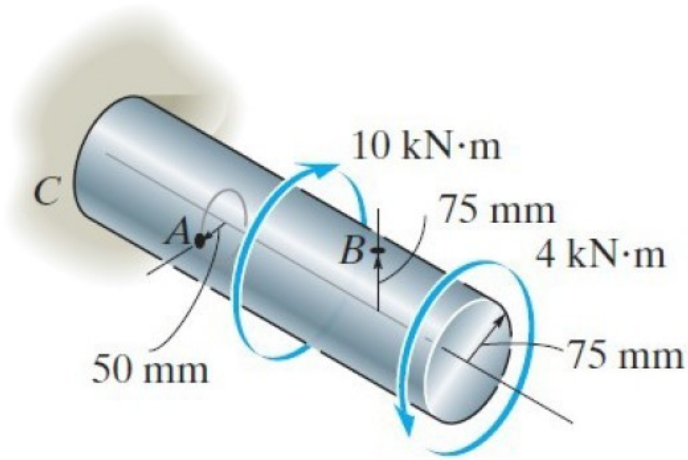
The solid shaft is fixed to the support at C and subjected to the torsional loadings shown. Determine the shear stress at points A and B and sketch the shear stress on volume elements located at these points.



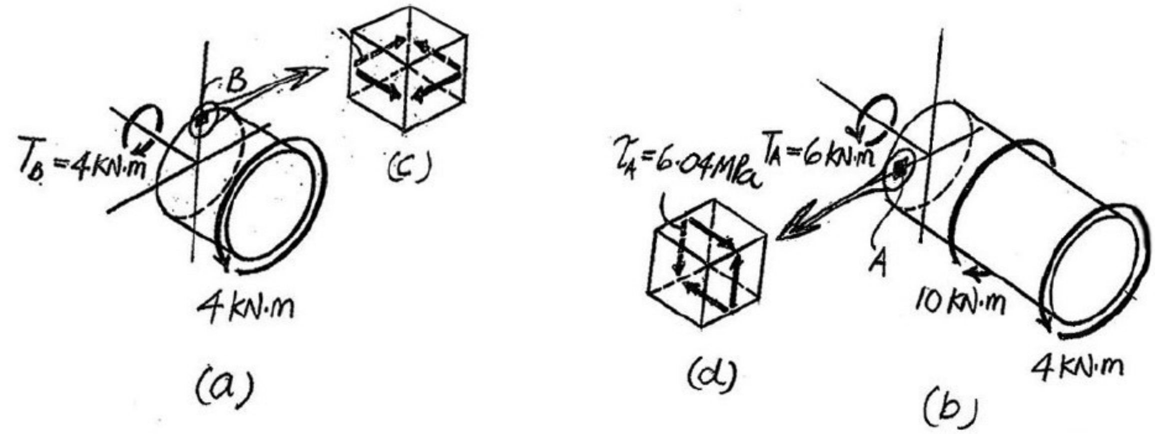
The internal torques developed at cross-sections passing through point B and A are shown in Fig. a and b, respectively.

The polar moment of inertia of the shaft is $J = \frac{\pi}{2}(0.075^4) = 49.70(10^{-6})\ \text{m}^4$. For point B, $\rho_B = C = 0.075$. Thus,

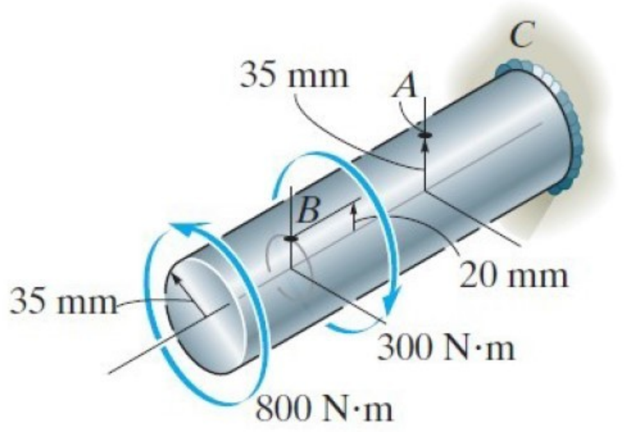
$$\tau_B = \frac{T_B c}{J} = \frac{4(10^3)(0.075)}{49.70(10^{-6})} = 6.036(10^6)\ \text{Pa} = 6.04\ \text{MPa} \qquad \textbf{Ans.}$$

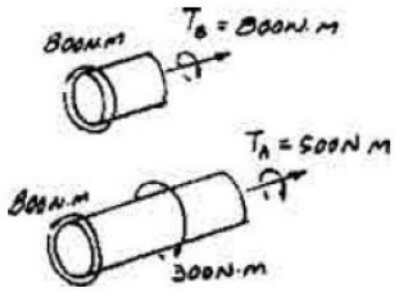
From point A, $\rho_A = 0.05$ m.

$$\tau_A = \frac{T_A \rho_A}{J} = \frac{6(10^3)(0.05)}{49.70\ (10^{-6})} = 6.036(10^6)\ \text{Pa} = 6.04\ \text{MPa}. \qquad \textbf{Ans.}$$



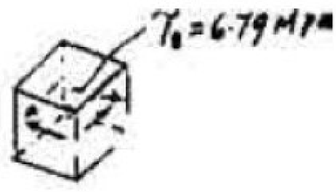
The solid shaft is fixed to the support at C and subjected to the torsional loadings shown. Determine the shear stress at points A and B on the surface, and sketch the shear stress on volume elements located at these points.

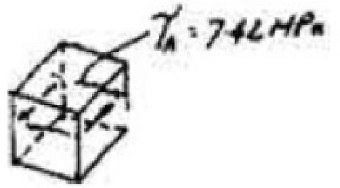




$$\tau_B = \frac{T_B\,\rho}{J} = \frac{800(0.02)}{\frac{\pi}{2}(0.035^4)} = 6.79\text{ MPa}$$

$$\tau_A = \frac{T_A\,c}{J} = \frac{500(0.035)}{\frac{\pi}{2}(0.035^4)} = 7.42\text{ MPa}$$





The A-36 solid steel shaft is 3 m long and has a diameter of 50 mm. It is required to transmit 35 kW of power from the engine E to the generator G. Determine the smallest angular velocity the shaft can have if it is restricted not to twist more than 1°.

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

$$\frac{1°(\pi)}{180°} = \frac{T(3)}{\frac{\pi}{2}(0.025^4)(75)(10^9)}$$

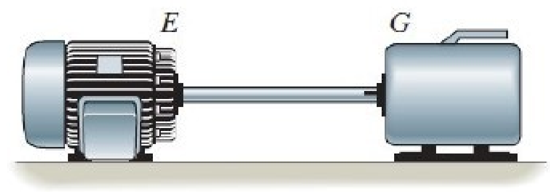
$$T = 267.73\ \text{N}\cdot\text{m}$$

$$P = T\omega$$

$$35(10^3) = 267.73(\omega)$$

$$\omega = 131\ \text{rad/s}$$

The A-36 hollow steel shaft is 2 m long and has an outer diameter of 40 mm. When it is rotating at it 80 rad/s, it transmits 32 kW of power from the engine E to the generator G. Determine the smallest thickness of the shaft if the allowable shear stress is τ_{Allow} = 140 MPa and the shaft is restricted not to twist more than 0.05 rad.



$$P = T\omega$$

$$32(10^3) = T(80)$$

$$T = 400\ \text{N}\cdot\text{m}$$

Shear stress failure

$$\tau = \frac{Tc}{J}$$

$$\tau_{allow} = 140(10^6) = \frac{400(0.02)}{\frac{\pi}{2}(0.02^4 - r_i^{\,4})}$$

$$r_i = 0.01875\ \text{m}$$

Angle of twist limitation:

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

$$0.05 = \frac{400(2)}{\frac{\pi}{2}(0.02^4 - r_i^{\,4})(75)(10^9)}$$

$$r_i = 0.01247\ \text{m} \qquad \text{(controls)}$$

$$t = r_o - r_i = 0.02 - 0.01247$$

$$= 0.00753\ \text{m}$$

$$= 7.53\ \text{mm}$$