3.9) a) $\tau_{AB} = \frac{Tc}{J}$

$$= \frac{300 \times \frac{30}{2} \times 10^{-3}}{\frac{\pi (30 \times 10^{-3})^4}{32}}$$

$= 56.588424421 MPa$

$\approx 56.4 MPa$

b) $\tau_{BC} = \frac{Tc}{J}$

$$= \frac{700 \times \frac{46}{2} \times 10^{-3}}{\frac{\pi (46 \times 10^{-3})^4}{32}}$$

$= 36.626435549 MPa$

$\approx 36.6 MPa$

3.16) $\tau_{max} = \frac{T_1 c}{J}$

$$100 \times 10^6 = \frac{T_1\left(\frac{36}{2} \times 10^{-3}\right)}{\frac{\pi (36 \times 10^{-3})^4}{32}}$$

$$T_1 = 916.0884178 \text{ Nm}$$

$$\simeq 916 \text{ Nm}$$

$$\tau_{max} = \frac{T_2 c}{J}$$

$$60 \times 10^6 = \frac{T_2\left(\frac{40}{2} \times 10^{-3}\right)}{\frac{\pi (40 \times 10^{-3})^4}{32}}$$

$$T_2 = 753.98223 69 \text{ Nm}$$

$$\simeq 754 \text{ Nm}$$

The largest torque is 754 Nm.

3.75) $T = \frac{P}{2\pi f}$

$= \frac{10 \times 10^3}{2\pi(25)}$

$= \frac{200}{\pi}\ Nm$

Stress requirement:

$\tau_{max} = \frac{Tc}{J}$

$30 \times 10^6 = \frac{16T}{\pi d^3}$

$30 \times 10^6 \pi d^3 = 16\left(\frac{200}{\pi}\right)$

$d = 22.109368788\ mm$

$\approx 22.1\ mm$

Twist angle requirement:

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

$4 \times \frac{\pi}{180} = \frac{32TL}{G\pi d^4}$

$\frac{77.2 \times 10^9 \pi^2 d^4}{45} = 32\left(\frac{200}{\pi}\right)(2.5)$

$d = 23.418894 74$

$\approx 23.4\ mm$

$\therefore$ The required diameter of the shaft is 23.4 mm.

3.(53)

a) $\phi = \frac{TL}{GJ}$

$$4 \times \frac{\pi}{180} = \frac{T(1.25)}{27\times10^9 \times \frac{1}{2}\left[\left(\frac{18}{1000}\right)^4 - \left(\frac{12}{1000}\right)^4\right]\pi}$$

$$T = \frac{12636}{625}\pi^2$$

$$T = 199.5397139 \text{ Nm}$$

$$\simeq 199.5 \text{ Nm}$$

b) Getting the diameter of the solid shaft

$$\frac{\pi d^4}{4} = \pi(18^2 - 12^2)$$

$$d = \sqrt{720} \text{ mm}$$

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

$$\phi = \frac{\frac{12636}{625}\pi^2(1.25)}{27\times10^9\,\pi\left[\frac{(\sqrt{720}\times10^{-3})^4}{32}\right]}$$

$$= 0.1815142422 \text{ rad}$$

$$= 10.4^\circ$$