

Solution for Q3

Consider FBD of the Int'l

$$\sum F_x = 0: N - 150\left(\frac{4}{5}\right) = 0 \Rightarrow N = 120 \text{ N}$$

$$\sum F_y = 0: 150\left(\frac{3}{5}\right) - V_y = 0 \Rightarrow V_y = 90 \text{ N}$$

$$\sum M_A = 0: 20 - M_t = 0 \Rightarrow M_t = 20 \text{ Nm}$$

$$\sum M_2 = 0: -150\left(\frac{3}{5}\right)(0.4) + 150\left(\frac{4}{5}\right)(0.125) + M_2 = 0$$

$$\Rightarrow M_2 = 21 \text{ Nm}$$

SECTION PROPERTIES:

$$A = \pi(0.005)^2 = 25\pi \times 10^{-6} \text{ m}^2$$

$$I_z = \frac{\pi}{4}(0.005)^4 = 0.15625\pi \times 10^{-9} \text{ m}^4$$

$$I_p = \frac{\pi}{2}(0.005)^4 = 0.3125\pi \times 10^{-9} \text{ m}^4$$

$$Q_A = 0$$

$$Q_B = \bar{y}'A' = \frac{4(0.005)}{3\pi} \left[\frac{\pi}{2}(0.005)^2 \right] = 83.33 \times 10^{-9} \text{ m}^3$$

NORMAL STRESS:

At point A: due to axial & bending moment

$$\sigma_A = \frac{N}{A} - \frac{M_z y}{I_{zz}} = \frac{-120}{25\pi \times 10^{-6}} - \frac{21(0.005)}{0.15625\pi \times 10^{-9}} = -215.4 \text{ MPa (C)} \quad \underline{\underline{\text{ANS}}}$$

For point B. $y = 0$

$$\therefore \sigma_B = \frac{N}{A} - \frac{M_z y}{I_{zz}} = \frac{-120}{25\pi \times 10^{-6}} - 0 = -1.53 \text{ MPa (C)} \quad \underline{\underline{\text{ANS}}}$$

SHEAR STRESS:

For point A: Trans. shear stress = 0 ($Q_A = 0$)

Torsional shear stress:

$$\tau_A^t = \frac{M_t R_o}{I_p} = \frac{20(0.005)}{0.3125\pi \times 10^{-9}} = 101.9 \text{ MPa} \quad \underline{\underline{\text{ANS}}}$$

For point B:

Trans. shear stress

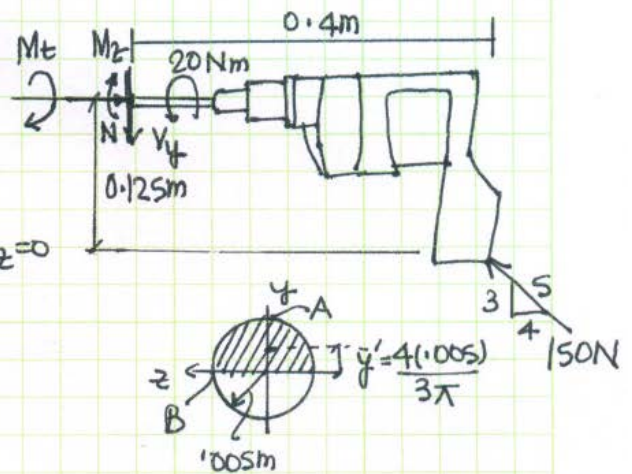
$$\tau_B^v = \frac{V_y Q_B}{I_b} = \frac{90(83.33 \times 10^{-9})}{(0.15625\pi \times 10^{-9})(0.01)} = 1.528 \text{ MPa}$$

Torsional shear stress:

$$\tau_B^t = \frac{M_t R_o}{I_p} = 101.9 \text{ MPa}$$

Total shear stress:

$$\tau = \tau_B^t - \tau_B^v = 101.9 - 1.52 = 100.4 \text{ MPa} \quad \underline{\underline{\text{ANS}}}$$



Grading Scheme

- FBD and calculating all force and moment components (marks have been deducted if all calculations are correct but FBD is not shown) – (6 marks)
- Correctly calculating polar moment of inertia (I_{xx}) and I_{zz} – (2 marks)
- Calculating torsional strain, axial strain due to axial force and shear flow (Q) – (6 marks)
- Calculating and reporting the correct stress components at A and B – (3 x 2 = 6 marks)