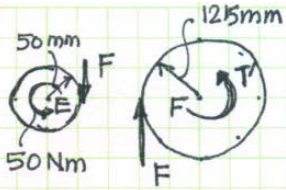
ESO 202A/204: Mechanics of Solids (2016-17 II Semester)
Assignment No. – 7 (Solution)

PROB #1



EQUILIBRIUM:

$\circlearrowleft \sum M_E = 0$: $50 - F(0.05) = 0 \Rightarrow F = 1000\ N$

$\circlearrowleft + \sum M_F = 0$ $\quad T' - F(.125) = 0$

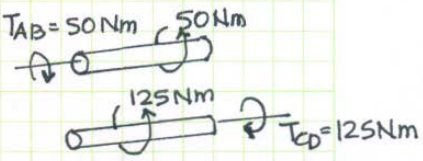
$T' - 1000(.125) = 0 \Rightarrow T' = 125\ Nm$ ANS

INTERNAL TORQUE:

As shown in Fig:

$T_{AB} = 50\ Nm$

$T_{CD} = 125\ Nm$.



MAX. SHEAR STRESS:

$$\tau_{AB}|_{max} = \frac{T_{AB}.R_o}{I_P} = \frac{50(0.015)}{\frac{\pi}{2}(.015^4)} = 9.43\ MPa \quad \text{ANS}$$

$$\tau_{CD}|_{max} = \frac{T_{CD}R_o}{I_P} = \frac{(125)(.0175)}{\frac{\pi}{2}(.0175^4)} = 14.8\ MPa \quad \text{ANS}$$

PROB. #2

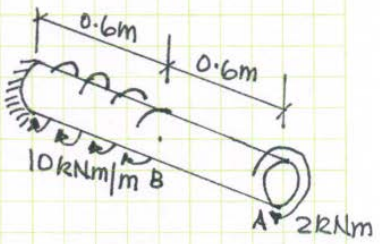
EQUILIBRIUM: FBD of AB

$\Sigma M_x = 0$; $-M_t^{AB} - 2000 = 0 \Rightarrow M_t^{AB} = -2000\ Nm$

FBD of segment BC

$\Sigma M_x = 0$: $-M_t^{BC} - (10000x) - 2000 = 0$

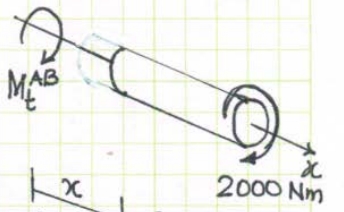
$\Rightarrow M_t^{BC} = -[10000x + 2000]\ Nm$



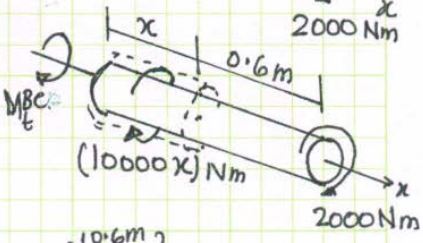
ANGLE OF TWIST:

$$I_p = \frac{\pi}{2}(0.04)^4 = 1.28\times10^{-6}\pi\ m^4$$

$$\phi_A = \sum \frac{M_t^i L_i}{I_{pi} G_i} = \left(\frac{M_t L}{I_P G}\right)_{AB} + \int_0^{L_{BC}} \frac{M_t^{BC}}{(I_P G)_{BC}}\,dx$$



$$= \frac{(-2000)(0.6)}{1.28\times10^{-6}\times\pi\times26\times10^9} + \int_0^{0.6m} \frac{-[10000x + 2000]\,dx}{(1.28\times10^{-6})\pi(26\times10^9)}$$

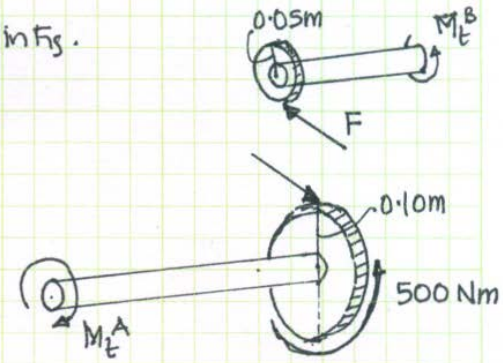


$$= -\frac{1}{(1.28\times10^{-6})\pi(26\times10^9)}\left\{1200 + (5000x^2 + 2000x)\Big|_0^{0.6m}\right\}$$

$$= -0.04017\ rad = \underline{2.30^\circ} \quad \text{ANS}$$

PROB. #3

EQUILIBRIUM: Consider FBD as shown in Fig.



$$M_t^A + F(0.1) - 500 = 0 \quad (1)$$

$$M_t^B - F(0.05) = 0 \quad (2)$$

From (1) & (2)

$$M_t^A + 2M_t^B - 500 = 0 \quad (3)$$

COMPATIBILITY:

$$0.1\,\phi_E = 0.05\,\phi_F$$

$$\Rightarrow \phi_E = 0.5\,\phi_F$$

$$\frac{M_t^A(1.5)}{I_p G} = 0.5\left[\frac{M_t^B(0.75)}{I_p G}\right]$$

$$M_t^A = 0.25\,M_t^B \quad (4)$$

Solving (3) & (4) yields

$$M_t^B = 222 \text{ Nm} \qquad \underline{\text{ANS}}$$

$$M_t^A = 55.6 \text{ Nm}$$