No.: CVDN PYP 2018 - 2019 Sem 2 Date:

1. a) $r_A = 5k$ $r_C = -3i - 3j$ $r_B = 4k$ $r_D = 3j$

$r_{AC} = -3i - 3j - 5k$ $r_{BD} = 3j - 4k$

$|r_{AC}| = \sqrt{3^2 + 3^2 + 5^2}$ $|r_{BD}| = \sqrt{3^2 + 4^2}$

$= 6.5574$ $= 5$

$F_1 = F_1 \cdot u = 250 \left(\frac{-3i - 3j - 5k}{6.5574}\right) = -114i - 114j - 191k$

$F_2 = F_2 \cdot u = 500 \left(\frac{3j - 4k}{5}\right) = 300j - 400k$

$F_R = -114i - 114j - 191k + 300j - 400k = -114i + 186j - 591k$

$\sqrt{114^2 + 186^2 + 591^2} = 630$

$M_1 = r_A \times F_1 = (-114 \times 5)i - (-114 \times 5)j$

$= 570i - 570j$

$\begin{array}{ccc} i & j & k \\ 0 & 0 & 5 \\ -114 & -114 & -191 \end{array}$

$M_2 = F_2 \times r_B = -(300 \times 4)i = -1200i$

$M_R = M_1 + M_2 = (-630i - 570j)\ Nm$

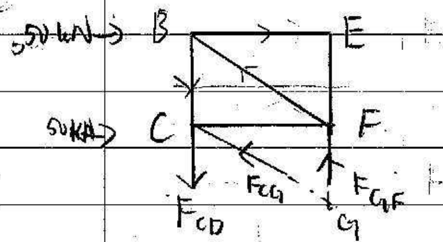
$\begin{array}{ccc} i & j & k \\ 0 & 0 & 4 \\ 0 & 300 & 400 \end{array}$

$r_{OC} = (-3i - 3j)$ $u_{OC} = \frac{1}{\sqrt{18}}(-3i - 3j)$

$M_{OC} = u \cdot M_R = (-0.707)(-630) + (-0.707)(-570)$

$= (445.1 + 403j)\ Nm$

b) BE, BC, CG



$\circlearrowleft + \Sigma M_G = 0$ $-50(2) - 50(4) + F_{CD}(4) = 0$

$F_{CD} = 75\ kN$

$\circlearrowleft + \Sigma M_F = 0$ $-50(2) + F_{BC}(4) = 0$

$F_{BC} = 25\ kN$

$F_{CG} = \frac{\sqrt{2^2 + 4^2}}{2} \times 75$

$= 167.7\ kN$

$F_{BF} = \frac{\sqrt{2^2 + 4^2}}{2} \times 25 = 55.9\ kN$

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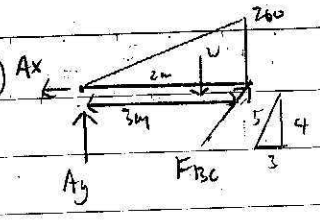
2. a)



$\circlearrowleft + \; \Sigma M_A = 0 \quad \left(-200 \times \frac{3}{2} \times 2\right) + \frac{4}{5}(F_{BC}) \times 3 =$

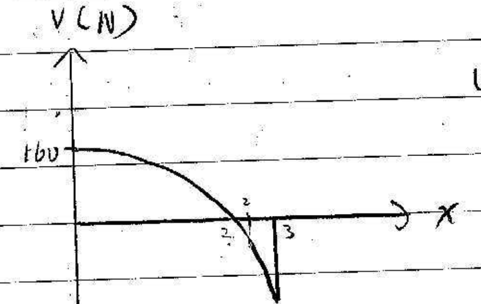
$F_{BC} = 250\,N$

$\rightarrow + \; \Sigma F_x = 0 \quad -A_x + \frac{3}{5}(250) = 0$

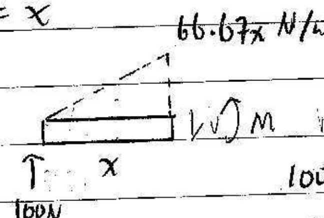
$A_x = 150\,N$

$\uparrow + \; \Sigma F_y = 0 \quad A_y + \left(-200 \times \frac{3}{2}\right) + \frac{4}{5}(250) = 0$

$A_y = 100\,N$



$w(x) = x$

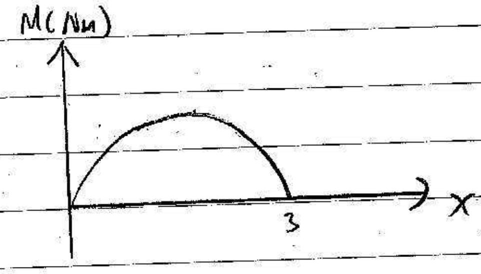


$100 - \frac{66.67x^2}{2} - V = 0$

$V = 100 - 33.335x^2$

$M - 100x + \frac{1}{3}(x)(33.335x^2) = 0$

$M = 100x - 11.11x^3$

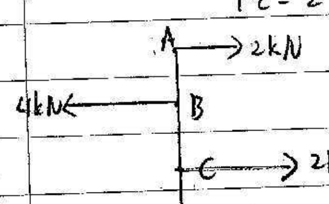


b) $\delta_T = \alpha \Delta T L$

$\Sigma M_C = 0 \quad -F_B(40) + 2000 \times 80 = 0 \qquad F_B = 4000\,kN$

$F_C = 2000\,kN$

Expansion Pure to deadlng



$\delta_{BE} = \frac{4000(80)}{100(200 \times 10^3)} = 0.016\,mm$

$\delta_{CF} = \frac{2000(100)}{100(200 \times 10^3)} = 0.01\,mm$

Compression due to temperature Δ

$\delta_{BE} \geq 0.016$

$0.016 = (12 \times 10^{-6})(x)(80)$

$x = 16.67°C$

The required temperature needs to be at least 16.

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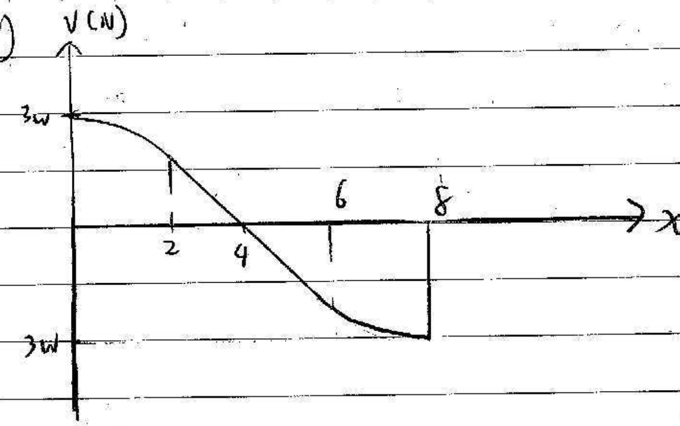
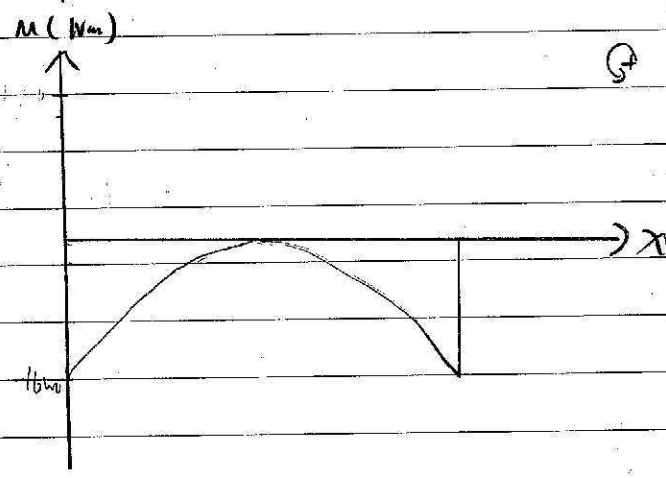
3. a)





$F_A = F_D = \frac{4w + 2w}{2} = 3w$

$T_a = \frac{VQ}{IB}$ $\quad Q = \left(\frac{\pi}{2}(0.06)^2 \times \frac{4\times}{3}\right.$

$= \frac{3w \times 1.44\times10^{-4}}{0.120 \times 1.0179^{-5}} = 1.44\times10^{-4}m^2$

$354w = T_a$

$w = 2.8275\times10^{-3} T_a$

$0 = M_A - \left(\frac{4}{3}(w_0)\right) - w_0(4)(4) - w_0(\frac{2}{3}$

$M_A = 16w_0$

$M_D = -16w_0$

$y_{max} = 0.06m$

$\sigma_a = \frac{My}{I}$ $\quad I = \frac{\pi}{4}(0.06)^4$

$\frac{16w(0.06)}{1.0179\times10^{-5}}$ $\quad = 1.0179\times10^{-5}m^4$

$w = 1.06\times10^{-5}\sigma_a$

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

$T = \frac{\tau J}{r}$

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

b) $J_B = \frac{\pi}{2}(0.015)^4 = 7.9522\times10^{-8}m^4$

$J_A = \frac{\pi}{2}(0.018^4 - 0.016^4) = 8.5374\times10^{-8}m^4$

$J_T = \frac{\pi}{2}(0.018^4) = 1.6489\times10^{-7}m^4$

$\tau_B = \frac{T_B r_B}{J_B} \Rightarrow T_B = \frac{\tau_B J_B}{r_B} = \frac{50\times10^6 \times 7.9522\times10^{-8}}{0.015} = 265\ Nm$

$T_A = \frac{\tau_A J_A}{r_A} = \frac{25\times10^6 \times 8.5374\times10^{-8}}{0.018} = 118.6\ Nm$

btw BC $\quad \frac{T_A \cancel{L_A}}{G_A J_A} = \frac{T_B \cancel{L_B}}{G_B J_B}$ $\quad T_A + T_B = T$ $\quad$ max Torque $= 265\ Nm$

$\frac{T_A}{26.5\times10^9 \times 8.5374\times10^{-8}} = \frac{T_B}{40\times10^9 \times 7.9522\times10^{-8}}$

$4.42\times10^{-4}\ T_A = 3.1438\times10^{-4}\ T_B$

$T_A = 0.71\ T_B$

$T = 1.71\ T_B$

if $T = 265$ $\quad T_B = 155\ Nm$

$T_A = 110\ Nm$

$\phi = \phi_{AB} + \phi_{BC}$

$= \frac{TL}{G_B J_B} + \frac{T_A L}{G_A J_A}$

$= \frac{265(2)}{40\times10^9 \times 7.952\times10^{-8}} + \frac{110(}{26.5\times10^9}$

$= 0.16 + 0.097$

$= 0.257\ rad$

$\phi_A = 0.0972$ $\quad \phi = 0.097$

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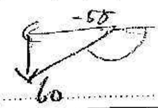

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4. $\sigma = \sigma_{avg} + \Delta\sigma \cos 2\theta + \tau_{xy} \sin 2\theta$

$= \sigma_{avg} + R\cos(\phi - 2\theta)$

$\sigma_1 = \sigma_{ave} + R$ at $\theta_1 = \frac{\phi}{2}$

$\sigma_2 = \sigma_{ave} - R$ at $\theta_2 = \theta_1 + \frac{\pi}{2}$

$\tau = -\Delta\sigma \sin 2\theta + \tau_{xy}\cos 2\theta$

$= R\sin(\phi - 2\theta)$

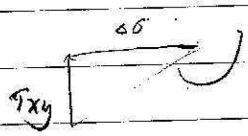
at $\theta_1 \mp \frac{\pi}{4}$

$\sigma_{avg} = \frac{\sigma_x + \sigma_y}{2}$ $\Delta\sigma = \frac{\sigma_x - \sigma_y}{2}$

$\sigma_{avg} = \frac{45}{2} = 22.5\ MPa$ $\Delta\sigma = 22.5\ MPa$

$\tau_{xy} = -30\ MPa$

$R = \sqrt{(-30)^2 + (22.5)^2} = 37.5\ MPa$



$\tan\phi = \frac{-30}{22.5} = -53.13 + 180° = 126.86°$

$25 = 22.5 + 37.5\cos(126.86° - 2\theta)$

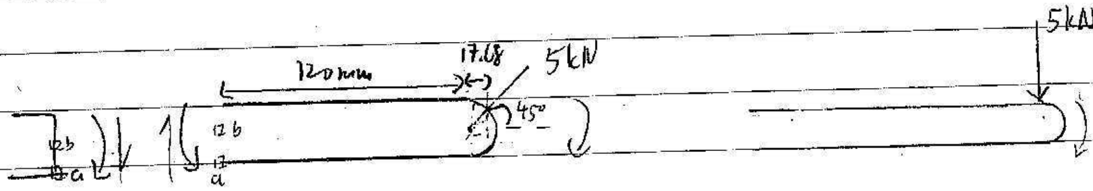
$126.86° - 2\theta = 86.177$

$\theta = 20.3°$

$50 = 22.5 + 37.5\cos(126.86° - 2\theta)$

$\theta = 42.0°$ $20.3° \le \theta \le 42.0°$

5.



$I_z = \frac{1}{12}(0.02)0.05^3$

$= 2.08 \times 10^{-7}\ m^4$

$I_y = \frac{1}{12}(0.025)(0.02)^3$

$= 3.33 \times 10^{-8}\ m^4$

$25 \cdot \cos 45° = 17.68$

Axial force $= 5\ kN \times \cos 45°$

$= 3.54\ kN$

Vertical force $= 5 \times \sin 45° = 3.54\ kN$

$Moment_z$ about b, $= 3.54 \times (0.138) = 0.4885\ kNm$

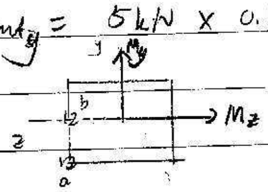
only shear at b $\tau = \frac{VQ}{Ib}$ $Q = 0.020 \times 0.025 \times 0.0125$

$= 6.25 \times 10^{-6}\ m^3$

$\tau_{max} = \frac{3540 \times 6.25 \times 10^{-6}}{2.08 \times 10^{-7} \times 0.02}$

$= 5.32\ MPa$

$Moment_y = 5\ kN \times 0.120 = 0.6\ kNm$



$\sigma = \frac{P}{A} - \frac{M_z y}{I_z} + \frac{M_y z}{I_y}$

$\sigma_a = \frac{-3540}{0.02 \times 0.05} - \frac{(-3540)(-0.025)}{2.08 \times 10^{-7}}$

$+ \frac{600(0.01)}{3.33 \times 10^{-8}} = -249\ M$

$\sigma_b = \frac{-3540}{0.02 \times 0.05} + \frac{600(0.01)}{3.33 \times 10^{-8}}$

$= 177\ MPa$

$\sigma_{ave_a} = \frac{-249}{2} = -124.5$ $\Delta\sigma_a = -124.5$ $\tau_a = 0$

$\tau_{max_a} = \sqrt{(-124.5)^2 + 0^2} = 124.5\ MPa$

$\tau_{b\,max} = \sqrt{\left(\frac{177}{2}\right)^2 + 5.32^2} = 88.65\ MPa$