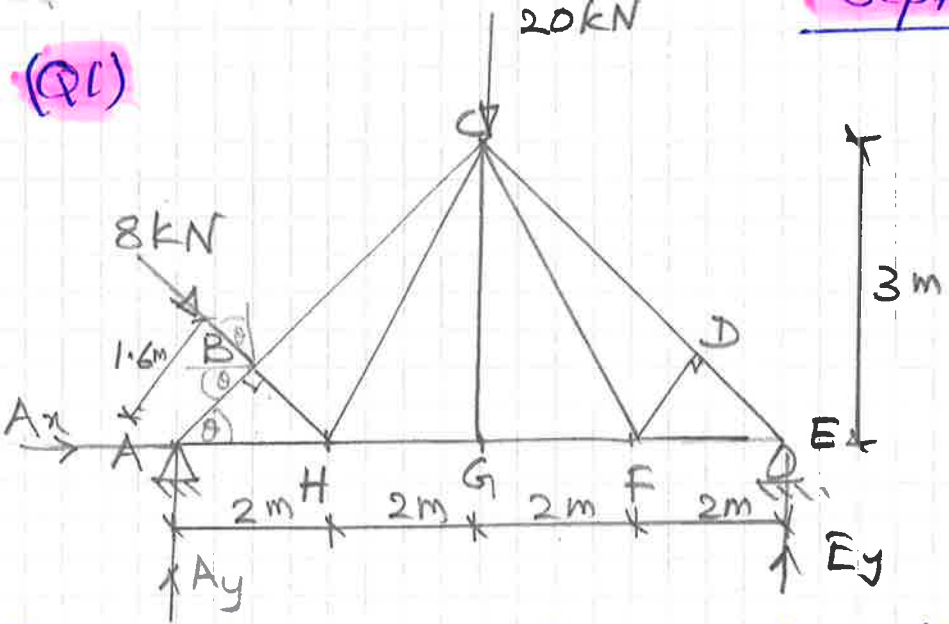
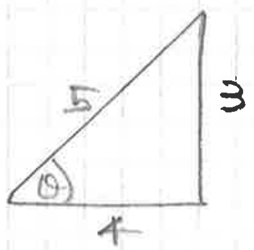
(Q1)



(1) considering equilibrium of entire truss

$\xrightarrow{+} \sum F_x = A_x + 8\sin\theta = 0$



$\tan\theta = \frac{3}{4}$

$\theta = \tan^{-1}(3/4) = 36.87^\circ$

$A_x = -(8 \times \frac{3}{5}) = -4.8\ kN$

$+\uparrow \sum F_y = A_y + E_y - 20 - 8\cos\theta = 0$

$A_y + E_y = 20 + (8 \times \frac{4}{5}) = 26.4$

taking moment about A,

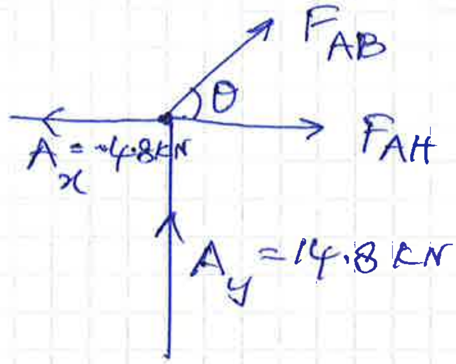
$\circlearrowleft\ 8E_y - (20 \times 4) - (8 \times 1.6) = 0$

$E_y = 11.6\ kN$

$A_y = 26.4 - 11.6$

$A_y = 14.8\ kN$

(II) considering equilibrium of joint A



$\uparrow \quad F_{AB} \sin\theta + 14.8 = 0$

$F_{AB} = \dfrac{-14.8}{(3/5)} = -24.67$ kN

$F_{AB} = 24.67$ kN (compression)

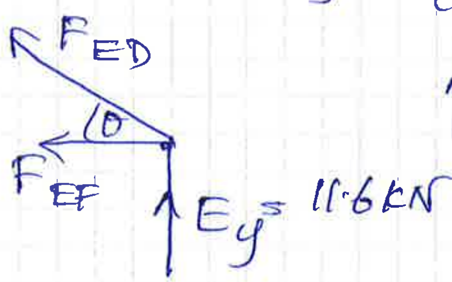
$\rightarrow \quad F_{AH} + F_{AB} \cos\theta - 4.8 \text{ kN} = 0$

$F_{AH} = 4.8 - (-24.67 \times 4/5)$

$F_{AH} = 24.53$ kN (Tension)

(III) zero force members CG, CF, DF

(IV) considering equilibrium of joint E.



$\uparrow \quad F_{ED} \sin\theta + 11.6 = 0$

$F_{ED} = \dfrac{-11.6}{(3/5)} = -19.33$ kN (Compression)

$F_{ED} = 19.33$ kN (compression)

$\leftarrow \quad F_{ED} \cos\theta + F_{EF} = 0$

$F_{EF} = -\left(-19.33 \times \dfrac{4}{5}\right) = 15.47$ kN.

$F_{EF} = 15.47$ kN (Tension)

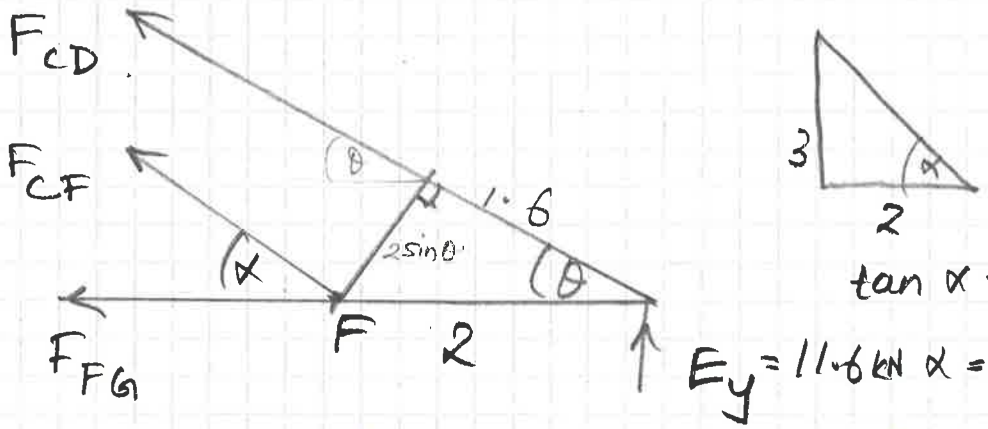
As DF and CF are zeroforce members

$F_{DE} = F_{CD} = $ 19·33 kN (compression)

$F_{EF} = F_{FG} = $ 15·47 kN (Tension)

Method II

From method of section.



$\tan\alpha = 3/2$

$E_y = 11{\cdot}6$ kN $\alpha = 56{\cdot}3^\circ$.

considering equilibrium of the segment

taking moment about F.

$$\circlearrowleft \ (F_{CD} \times 2\sin\theta) + (11{\cdot}6 \times 2) = 0$$

$$F_{CD} = -\frac{(11{\cdot}6 \times 2)}{(2 \times 3/5)} = -19{\cdot}33 \text{ kN}$$

$$F_{CD} = 19{\cdot}33 \text{ kN (Compression)}$$

$$\uparrow \quad F_{CD}\sin\theta + E_y + F_{CF}\sin\alpha = 0$$

$$F_{CF}\sin\alpha = (-E_y - F_{CD} \times \sin\theta)$$

$$= -11{\cdot}6 - \left(-19{\cdot}33 \times \frac{3}{5}\right)$$

$$F_{CF} = 0 \quad \text{(zero force member)}$$

$$\leftarrow \quad F_{FG} + F_{CF}\cos\alpha + F_{CD}\cos\theta = 0 \quad (F_{CF}\cos\alpha \to 0)$$

$$F_{FG} = -F_{CD}\cos\theta = -\left(-19{\cdot}33 \times \frac{4}{5}\right)$$

$$F_{FG} = 15{\cdot}47 \text{ kN (tension)}$$

(V) Required cross sectional area

$F_{DE} = 19.33\ kN$

$F_{EF} = 15.47\ kN$

(considering bigger value for area calculation)

$$\sigma_{All} \geq \frac{Force}{Area} = \frac{19.33 \times 10^3\ N}{area}.$$

$$area \geq \frac{19.33 \times 10^3\ N}{150\ N/mm^2} = 128.89\ mm^2$$

Required area for both can be $130\ mm^2$

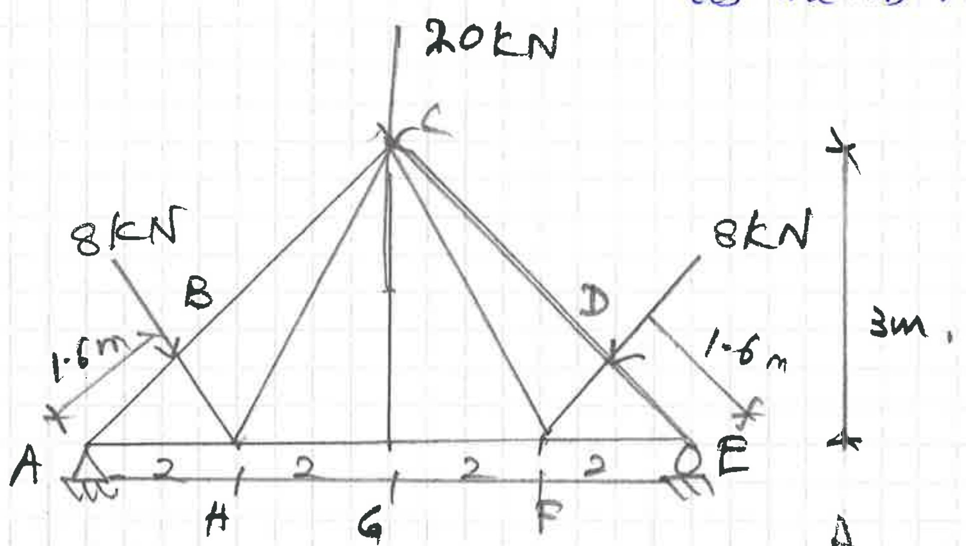
(VI) Change in length for CE

$$\frac{F}{A} = E\frac{\Delta}{L}$$

$$\Delta = \frac{FL}{AE} = \frac{19.33 \times 10^3 N \times 5m}{(130 \times 10^{-6}) m^2 \times 200 \times 10^9} = 0.00372\ m$$

$\Delta = 3.72\ mm.$ Contracted as member is compression

(VII)



problem is symmetric problem

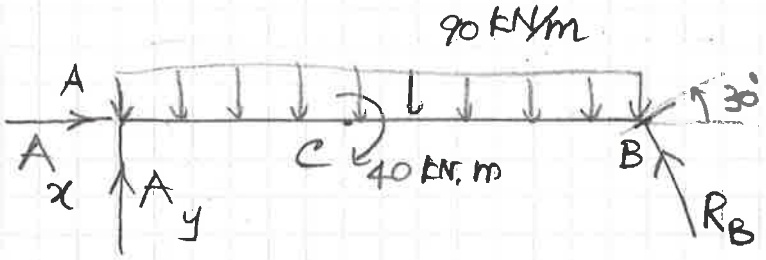
magnitude of member force will be bigger than previously

$A_x = 0$

$A_y = E_y$ = bigger value

(Q2)

(1) Free body diagram (FBD)



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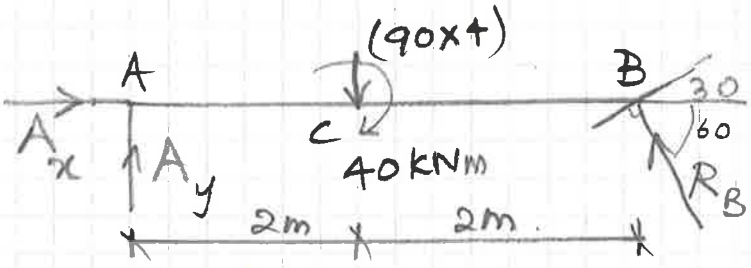


Considering equilibrium

$$\rightarrow \Sigma F_x = A_x - R_B \cos 60 = 0 \quad \text{——— (1)}$$

$$\uparrow \Sigma F_y = A_y - (90 \times 4) + R_B \sin 60 = 0 . \text{——— (2)}$$

taking moment about A,

$$\circlearrowright (R_B \sin 60 \times 4) - 40 - (90 \times 4 \times 2) = 0$$

$$\underline{\underline{R_B = 219.4 \text{ kN}}}$$

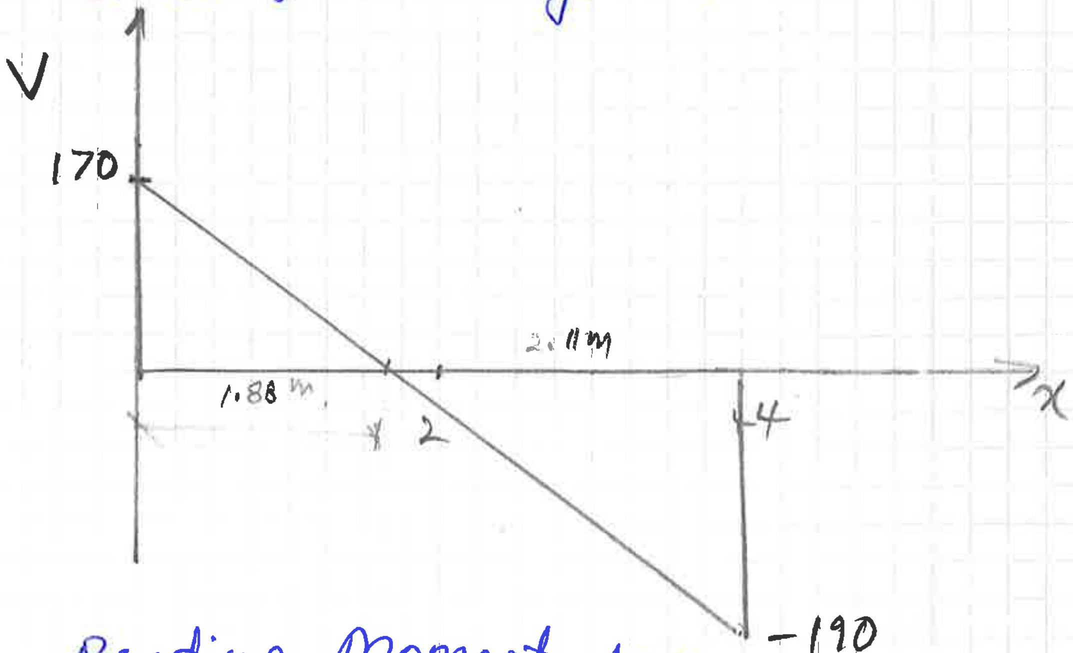
(1) ⇒ $A_x = 219.4 \cos 60$

$$\underline{\underline{A_x = 109.7 \text{ kN}}}$$

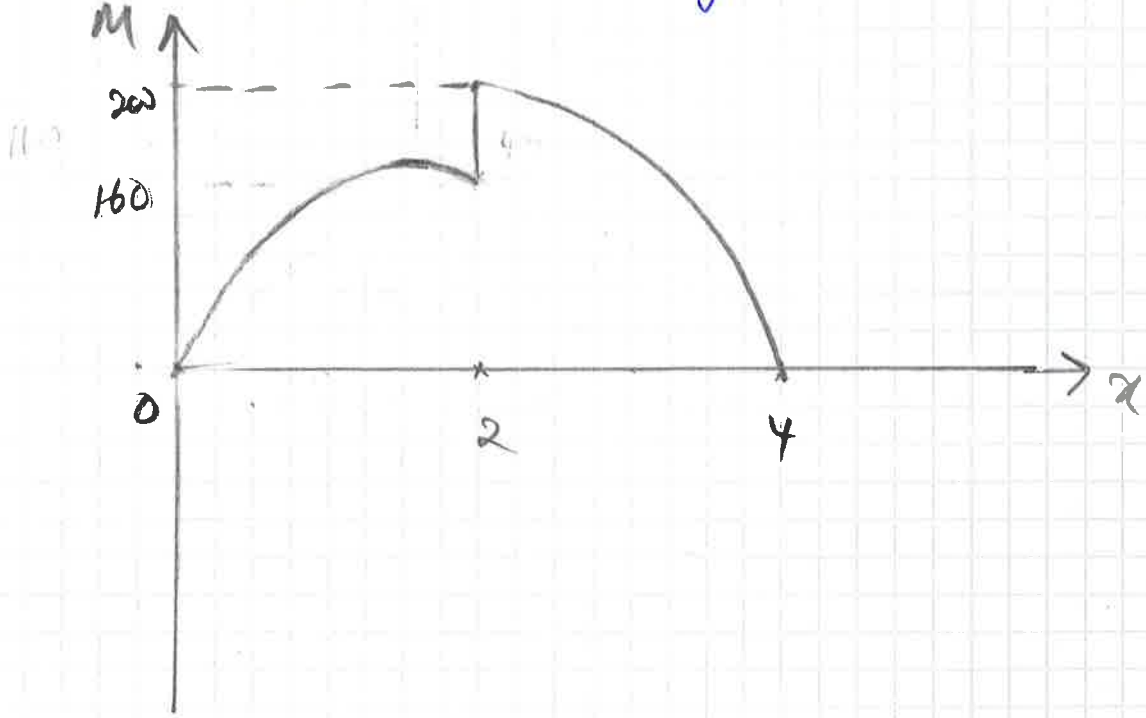
(2) ⇒ $A_y = (90 \times 4) - (219.4 \sin 60)$

$$\underline{\underline{A_y = 170 \text{ kN}}}$$

(ii) Shear force diagram

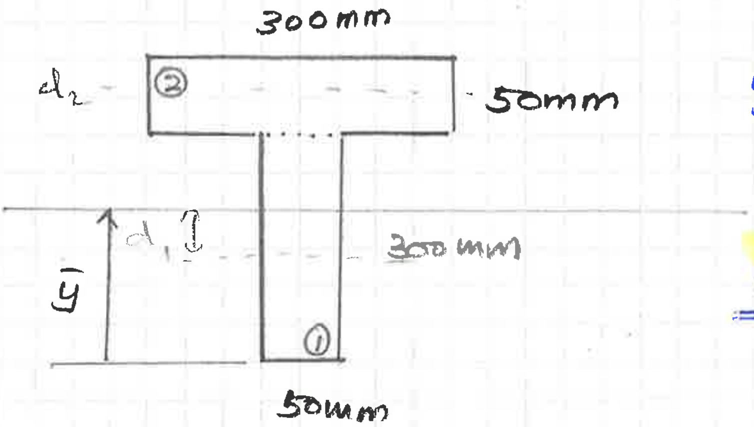


Bending Moment diagram



(iii) Cross sectional area $= (300 \times 50) + (300 \times 50) = 30000\, mm^2$

$= 0.03\, m^2$



$$\bar{y} = \frac{(300 \times 50)\,150 + (300 \times 50)\,325}{(300 \times 50) + (300 \times 50)}$$

$$\bar{y} = 237.5\ mm$$

$$I = (I_1 + A_1 d_1^2) + (I_2 + A_2 d_2^2)$$

$$= \left\{\left(\frac{1}{12} \times 50 \times 300^3\right) + \left(50 \times 300 \times (237.5 - 150)^2\right)\right\} +$$

$$\left\{\left(\frac{1}{12} \times 300 \times 50^3\right) + \left(50 \times 300 \times (112.5 - 25)^2\right)\right\} =$$

$$= 3.453 \times 10^{+8}\, mm^4$$

$$= 3.453 \times 10^{-4}\, m^4$$

(iv) maximum normal stress

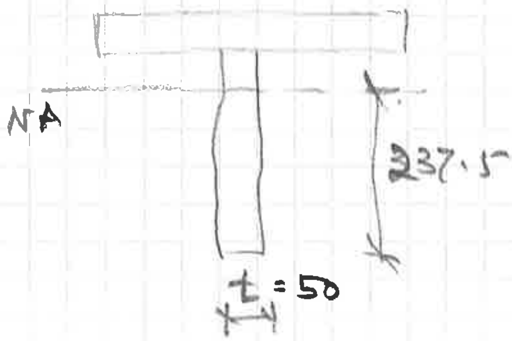
$$\sigma_{max} = \frac{M_{max}}{I} y_{max} - \frac{N_{max}}{A}$$

$$= \left(\frac{200 \times 10^3 \times 237.5 \times 10^3}{3.453 \times 10^{8}}\right) - \frac{109.7 \times 10^3}{0.03 \times 10^6}$$

$$= (137.557\ Mpa) - (3.659\ Mpa)$$

$$= 133.9\ mpa$$

$$\tau_{max} = \frac{VQ}{It}$$



$$= \frac{190 \times 10^3 \, [Q]}{3.453 \times 10^8 \times 50}$$

$$Q_{max} = \Sigma A'\bar{y}' = (237.5 \times 50) \times \frac{237.5}{2} = 1.41 \times 10^6 \, mm^3$$

$$\tau_{max} = \frac{190 \times 10^3 \times 1.41 \times 10^6 \, mm^3}{3.453 \times 10^8 \times 50}$$

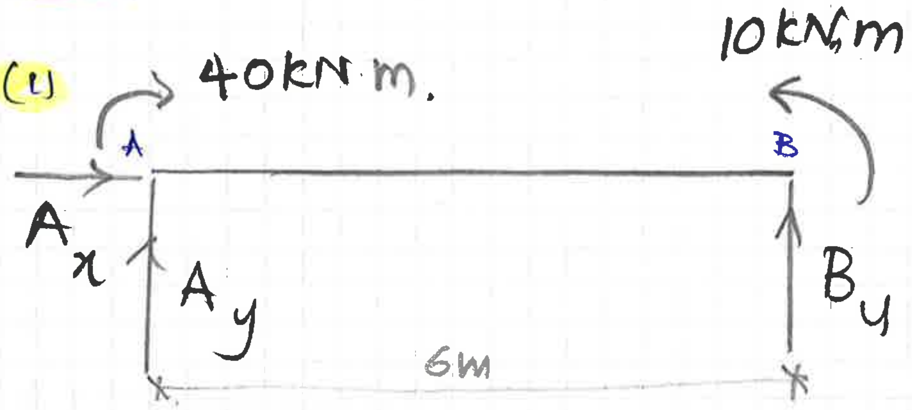
$$\tau_{max} = 15.519 \text{ Mpa}$$

(v) If angle of the support B is changed to 0°. axial force will be zero. Then maximum normal stress will be bigger

$$\sigma_{max} = \sigma_{\text{due to bending}} - \underbrace{\sigma_{axial}}_{=0}$$

(Q3)

(i)



considering equilibrium,

$\rightarrow \Sigma F_x = A_x = 0$

$\uparrow \Sigma F_y = A_y + B_y = 0$

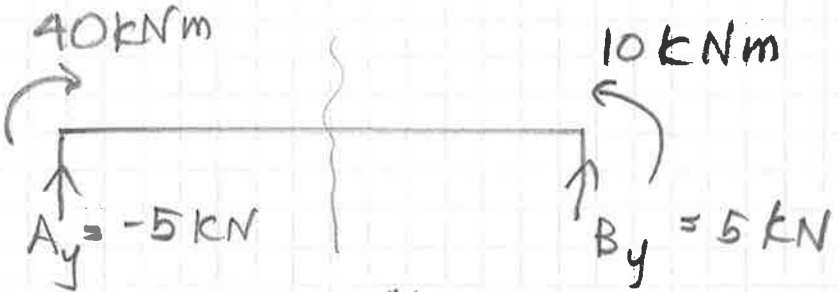
taking moment about A,

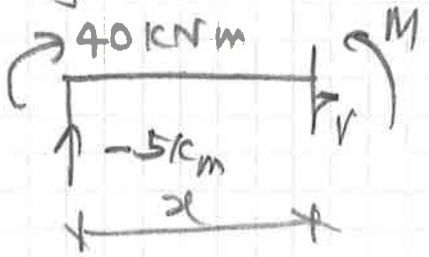
$\circlearrowleft (B_y \times 6) + 10 - 40 = 0$

$B_y = 30/6 = 5\ kN$

$A_y = -5\ kN$

(ii)



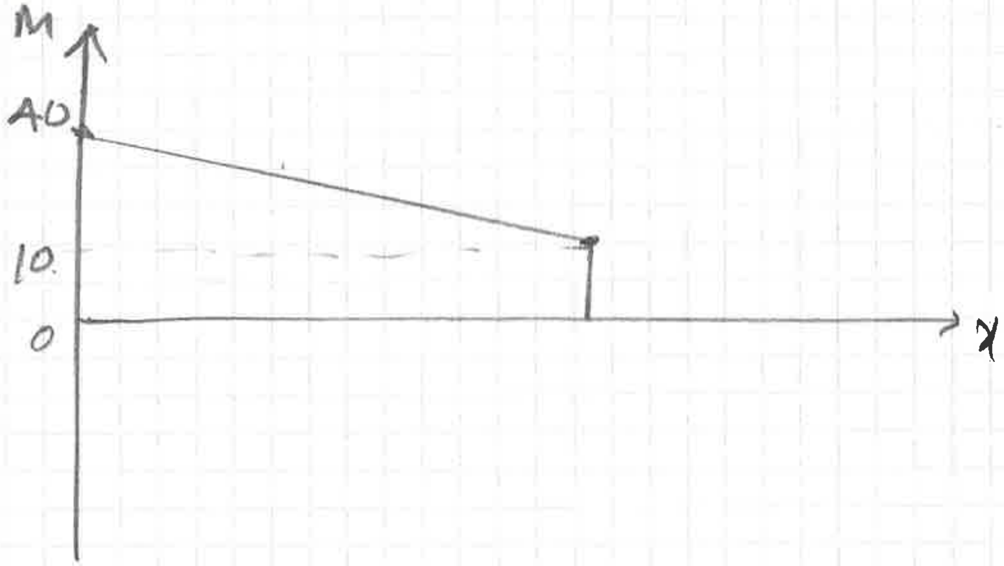


$0 < x < 6$

$\circlearrowleft$ $M - 40 - (-5x) = 0$

$M = 40 - 5x.$

x	M
0	40
3	25
6	10



(III) moment of inertia.

$$I = \left(\frac{1}{12} \times 200 \times 250^3\right) - \left[\frac{1}{12}(200-12.5)(225)^3\right]$$

$$= 8.244 \times 10^7 \text{ mm}^4$$

(IV) Deflection at point C.

$$EI \frac{d^2y}{dx^2} = M(x) = (40 - 5x)$$

$$EI \frac{dy}{dx} = 40x - \frac{5x^2}{2} + C_1$$

$$EI\, y(x) = 40\frac{x^2}{2} - \frac{5x^3}{6} + C_1 x + C_2$$

Boundary conditions.

$x = 0$, $y = 0$. then $C_2 = 0$

$x = 6$ $y = 0$

$$0 = 20(6^2) - \left(\frac{5 \times 6^3}{6}\right) + C_1 6$$

$$C_1 = -90$$

$$EI\, y(x) = 20x^2 - \frac{5}{6}x^3 - 90x.$$

when $x = 3$

(displacement at C)

$$y_{(x=3)} = \left\{(20\times 3^2) - \left(\frac{5}{6}\times 3^3\right) - (90\times 3)\right\} / EI$$

$E = 200\,GPa = 200\times 10^3\,mpa$ (Given)

$I = 8.244\times 10^7\,mm^4$ (calculated)

$$= \frac{-112.5\times 10^3}{200\times 10^9 \times 8.244\times 10^{-5}}\ m$$

$$= -6.823\,mm.$$

(v) maximum displacement can not be seen at C.

- To get maximum displacement, we can derivate the equation of deflection.

. When $\frac{dy}{dx} = 0$ (gradient = 0), we can find the maximum displacement/deflection.

And $\frac{d^2y}{dx^2} < 0$ is also satisfied.

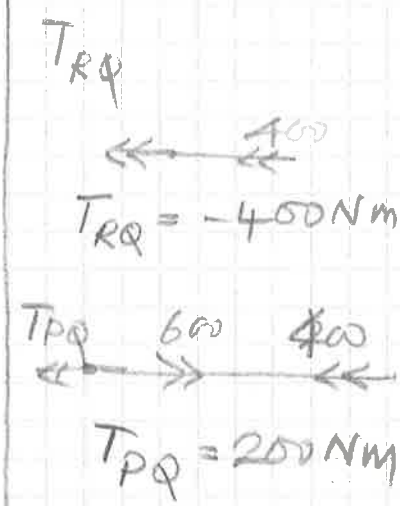
(Q 4)

(i) Angle of twist at the end R.

$$\phi_{R/P} = \phi_{R/Q} + \phi_{Q/P}$$

$$= \frac{T_{RQ}\, L_{RQ}}{GJ} + \frac{T_{QP} \cdot L_{QP}}{GJ}$$

$$= \left[(-400 \times 2) + (200 \times 2)\right] \frac{1}{GJ}.$$



$G = 75 \text{ GPa}$

$J = \frac{\pi}{2}(0.02)^4$

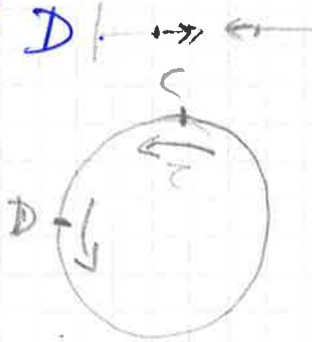
$$\phi_{R/P} = \frac{-200 \times 2 \quad Nm^2}{75 \times 10^9 \frac{N}{m^2} \cdot \frac{\pi}{2}(0.02)^4}$$

$= -0.0212 \text{ Rad} \quad = -1.216^\circ$

(ii) Stress due to torsion at point D.

$$\tau = \frac{T\rho}{J} = \frac{200 \times 10^3 \, Nmm \times 20mm}{\pi/2\,(20)^4}$$

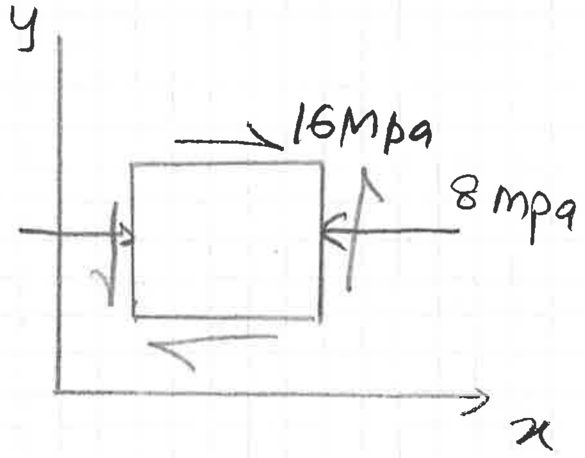
$= 15.91 \text{ Mpa}.$

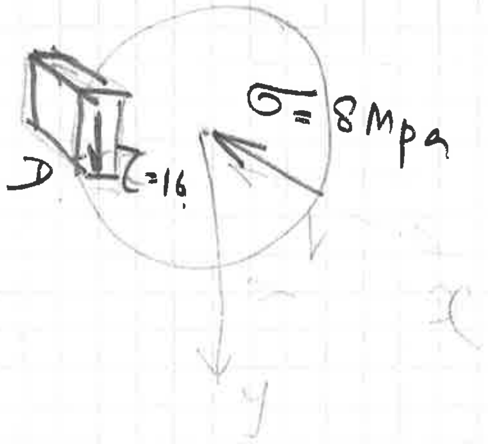


Stress due to axial force. (compressive force.)

$$\sigma = \frac{-10\times10^3 N}{\pi\times 20^2\ mm^2} = -7.96\ mpa.$$

(III)





(IV) principple stresses at point D.

$\sigma_x = -8$ Mpa

$\sigma_y = 0$

$\tau_{xy} = 16$ Mpa

$$\sigma_{1,2} = \left(\frac{\sigma_x+\sigma_y}{2}\right) \pm \sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= \left(\frac{-8+0}{2}\right) \pm \sqrt{\left(\frac{-8-0}{2}\right)^2 + 16^2}$$

$$= -4 \pm 16.492$$

$\sigma_1 = 12.49.$ Mpa $\qquad \sigma_2 = -20.49$ Mpa.

$$\tan 2\theta_p = \frac{\tau_{xy}}{(\sigma_x-\sigma_y)/2} = \frac{16}{(-8-0)/2} = -4$$

$$2\theta_p = -75.96^\circ$$

$$\theta_p = -37.98^\circ$$

(v) $\tau_{\text{in plane max}} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$

$= \sqrt{\left(\frac{-8}{2}\right)^2 + 16^2}$

$= 16.49$ mpa.

$\tau_{abs, max} = \frac{12.49 - (-20.49)}{2}$

$= 16.49$ mpa.

(vi) when shaft is a hollow shafter.
J will be small.

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

Then angle of twist will increase.

$J \Rightarrow \downarrow$ $\qquad \phi \uparrow$