CV1011 AY 2022-2023 Semester 2

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1 a) T_1 can be decomposed into three parts

$$L_{BC} = \sqrt{3^2+4^2+(4+2+3)^2} = \sqrt{106}$$

$$\vec{T}_1 = \frac{4}{\sqrt{106}} T_1 \hat{i} + \frac{3}{\sqrt{106}} T_1 \hat{j} - \frac{9}{\sqrt{106}} T_1 \hat{k}$$

$$\vec{r}_{AB} = 0\hat{i} + 0\hat{j} + 9\hat{k}$$

$$\vec{M}_{T_1} = \vec{r}_{AB} \times \vec{T}_1$$

$$\vec{M}_{T_1} = 9\hat{k} \left(\frac{4}{\sqrt{106}} T_1 \hat{i} + \frac{3}{\sqrt{106}} \hat{j} - \frac{9}{\sqrt{106}} \hat{k}\right)$$

$$\vec{M}_{T_1} = \frac{36}{\sqrt{106}} T_1 \hat{j} - \frac{27}{\sqrt{106}} T_1 \hat{i} + 0\hat{k}$$

$$\vec{M}_{T_1} = -\frac{27}{\sqrt{106}} T_1 \hat{i} + \frac{36}{\sqrt{106}} T_1 \hat{j} + 0\hat{k} = -2.622\, T_1 \hat{i} + 3.495\, T_1 \hat{j}$$

b) $\vec{M}_{T_2} = 0\hat{i} - 6T_2 \hat{j} + 0\hat{k}$

$$\vec{M}_{30kN} = 120\hat{i} + 0\hat{j} + 0\hat{k}$$

$$\Sigma \vec{M}_A = 0$$

$$\vec{M}_{T_1} + \vec{M}_{T_2} + \vec{M}_{30kN} = 0$$

$$\left(-\frac{27}{\sqrt{106}} T_1 + 120\right)\hat{i} + \left(\frac{36}{\sqrt{106}} T_1 - 6T_2\right)\hat{j} + 0\hat{k} = 0$$

$$\Downarrow \qquad\qquad \Downarrow$$

$$T_1 = 120 \times \frac{\sqrt{106}}{27} \qquad T_2 = \frac{6}{\cancel{\sqrt{106}}} \times 120 \frac{\cancel{\sqrt{106}}}{27}$$

$$T_1 = 45.758\text{ kN} \qquad T_2 = 26.667\text{ kN}$$

c) $\Sigma F = 0$

$\vec{A} + \vec{T_1} + \vec{T_2} + (-30\hat{j}) = 0$

$\vec{A} = -\left(\frac{4\times120}{27}\hat{i} + \frac{3\times120}{27}\hat{j} - \frac{9\times120}{27}\hat{k}\right) - \left(-\frac{6\times120}{27}\hat{i}\right) - (-30\hat{j})$

$\vec{A} = \underbrace{8.889}_{A_x}\hat{i} + \underbrace{16.667}_{A_y}\hat{j} + \underbrace{40}_{A_z}\hat{k}$

2a) $M_A = 0$

$4\times3\times\frac{3}{2} + 24 - 12\times8.5 + V_E\times10 = 0$

$V_E = 6\ kN \downarrow$

$\Sigma F_y = 0$

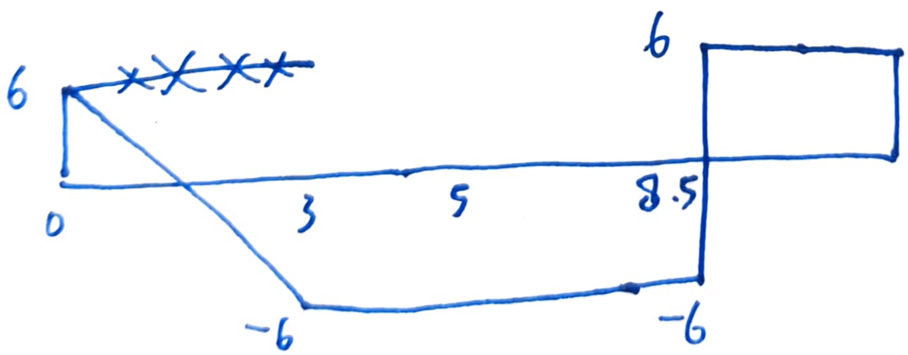
$V_A - 4\times3 + 12 - 6 = 0$

$V_A = 6\ kN \uparrow$

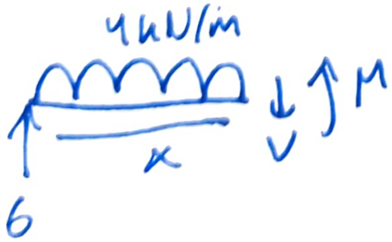
$\Sigma F_x = 0$

$H_A = 0\ kN$

b) SFD



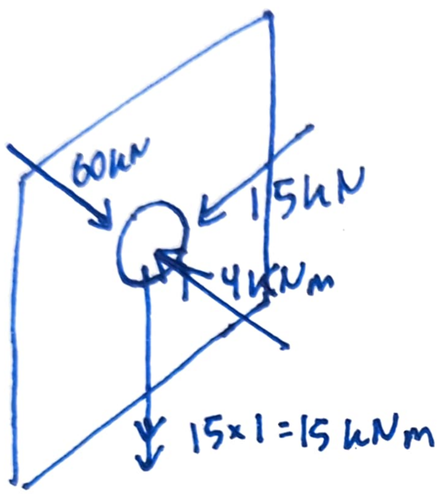
c)



$M = 6x - 4x\cdot\frac{x}{2}$

$M = 6x - 2x^2 \quad (0 \le x \le 3)$

3a)



b) $\theta = \frac{TL}{GJ}$

$$\theta = \frac{(4\times10^6)\times(500)}{(90\times10^3)\times(\frac{1}{2}\pi\times150^4)} \times \frac{180}{\pi}$$

↗ convert to degree

$\theta = 0.0016$ degree counterclockwise

c) Normal due to 60kN axial

$$\sigma = \frac{60000}{\pi\times150^2} = 0.849\text{MPa}$$

Normal due to 15kNm moment

$$\sigma = \frac{My}{I} = 0 \quad (y=0)$$

Shear due to 4kNm torsion

$$\tau = \frac{(4\times10^6)\times(150)}{\frac{1}{2}\pi\times150^4} = 0.755\text{MPa} (\leftarrow)$$

Shear due to 15kN

$$\tau = \frac{15000\times\frac{1}{2}\pi\times150^2\times\frac{4\times150}{3\pi}}{\frac{1}{4}\pi\times150^4\times300}$$

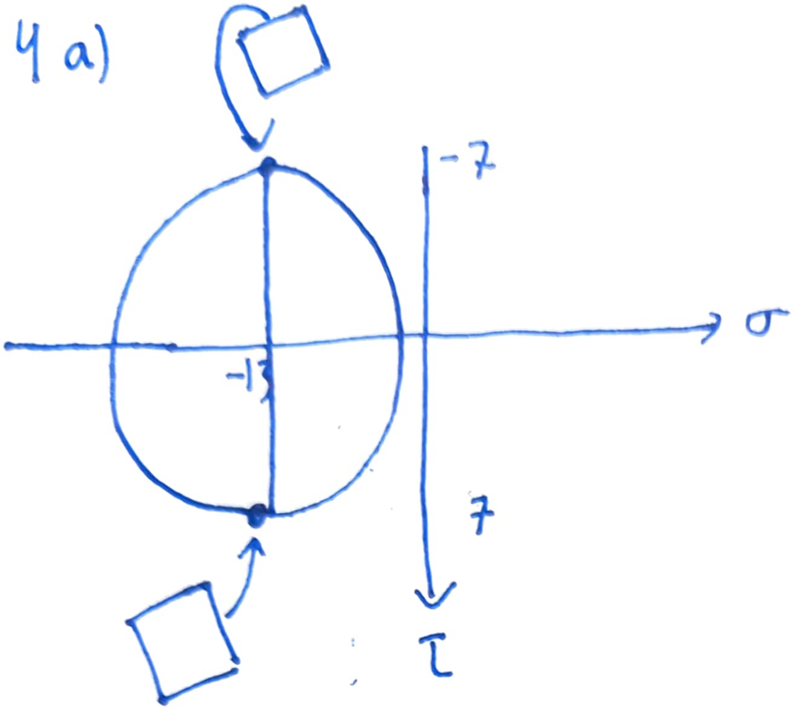
$\tau = 0.283\text{Mpa} (\rightarrow)$

Resultant

$\sigma = 0.849$ MPa

$\tau = 0.472$ MPa $(\leftarrow)$

4 a)

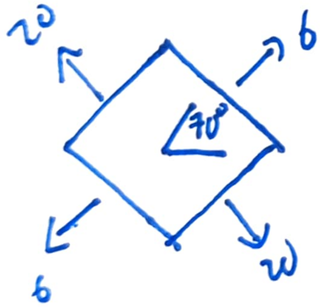


principal stresses

$\sigma_1 = -13 + 7 = -6$ MPa tensile

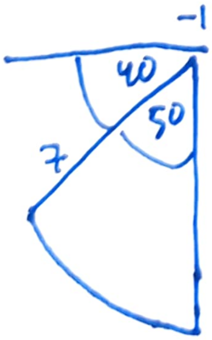
$\sigma_2 = -13 - 7 = -20$ MPa tensile

turn $\frac{90}{2} = 45$ degree from 25° (either way)



turn 25 degree clockwise from 25° to get 0°

$25 \times 2 = 50$ degree CW turn in mohr circle

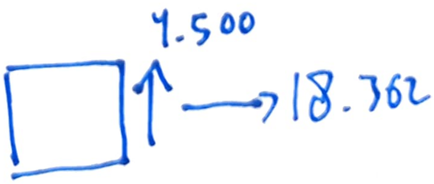


$\sigma = -13 - 7\cos 40$

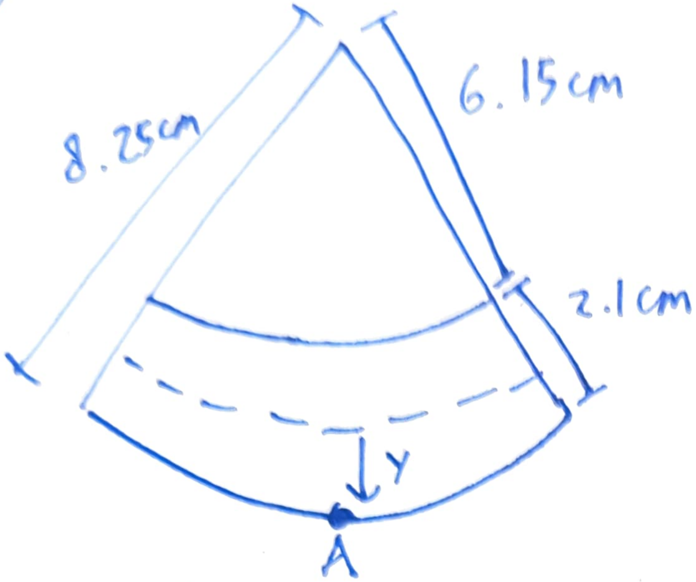
$\sigma = -18.362$ MPa

$\tau = 7 \sin 40$

$\tau = 4.500$ MPa



4b)



$$R = \frac{8.25 + 6.15}{2} = 7.2\,\text{cm} = 72\,\text{mm}$$

at point A

$$\varepsilon = \frac{y}{R}$$

$$\sigma = E\varepsilon$$

$$\frac{My}{I} = E\frac{y}{R}$$

$$M = \frac{EI}{R}$$

square b = h

$$M = \frac{25 \times \frac{1}{12} \times 21^4}{72} \times 10^{-3}$$

$$M = 5.627\,\text{Nm}$$