

7/5/20 @ 13:00 - CAE and Stress Analysis (M5X02064)

Q3. a.)

$$M_{xx} = EI \frac{d^2 y}{dx^2}$$

$$M_{xx} = \frac{W}{2} \left(\frac{L}{2} - x \right)$$

$$\therefore EI \frac{d^2 y}{dx^2} = \frac{WL}{4} - \frac{Wx}{2}$$

$$\therefore EI \frac{dy}{dx} = \frac{WL}{4} x - \frac{Wx^2}{2} + A$$

$$\therefore EI y = \frac{WLx^2}{8} - \frac{Wx^3}{12} + Ax + B$$

When $x=0$ $\frac{dy}{dx} = 0 \therefore 0 = A$

When $x = L/2$ $y=0 \therefore 0 = \frac{WL}{8} \left(\frac{L}{2} \right)^2 - \frac{W}{12} \left(\frac{L}{2} \right)^3 + B$

$$\therefore B = \frac{WL^3}{96} - \frac{WL^3}{32}$$

$$= \frac{WL^3}{96} - \frac{3WL^3}{96}$$

$$= -\frac{2WL^3}{96} = -\frac{WL^3}{48}$$

$$EI y = \frac{WLx^2}{8} - \frac{Wx^3}{12} + Ax + B$$

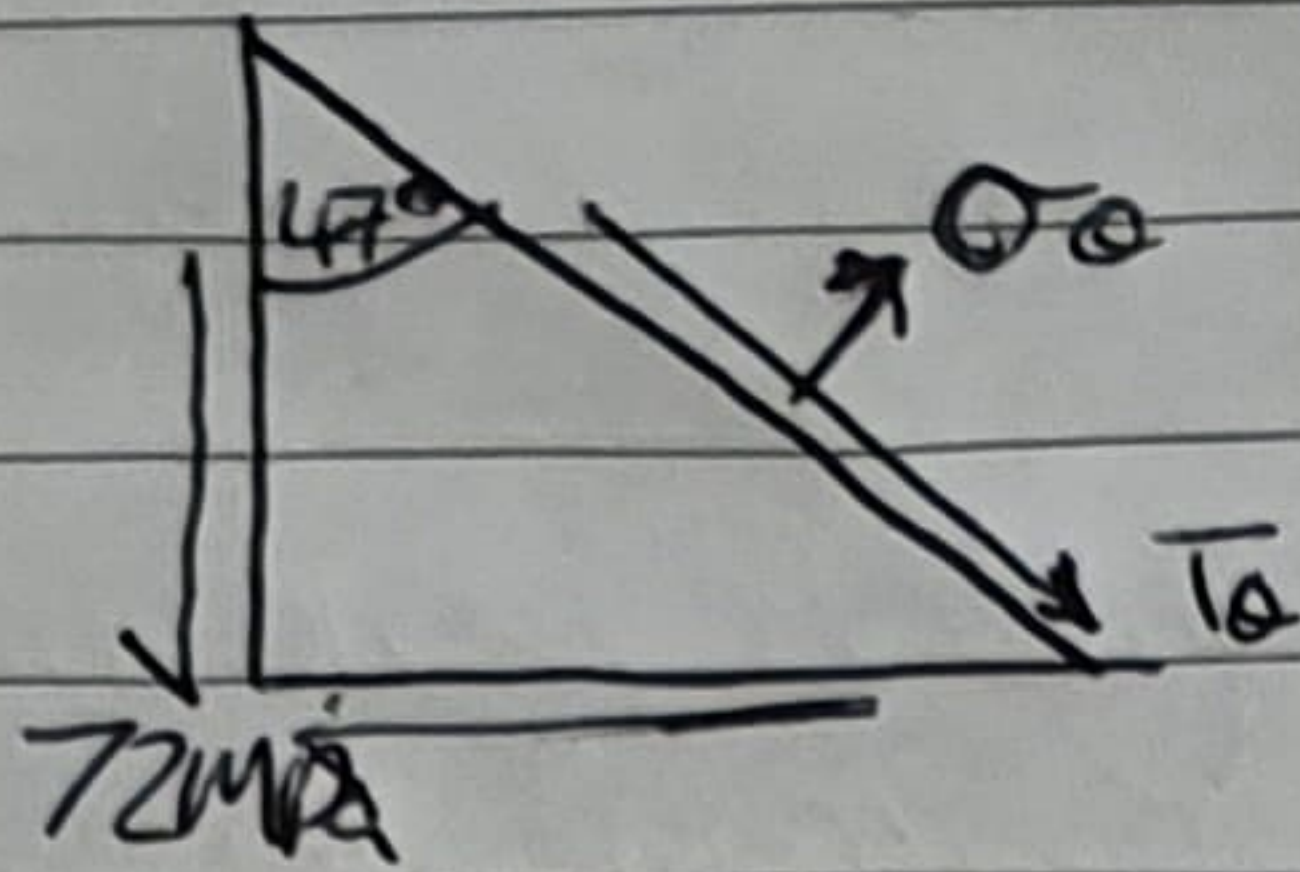
$$= \frac{WLx^2}{8} - \frac{Wx^3}{12} + 0 + -\frac{WL^3}{48}$$

$$= \frac{WLx^2}{8} - \frac{Wx^3}{12} - \frac{WL^3}{48}$$

$$\therefore y = \frac{1}{EI} \left[\frac{WLx^2}{8} - \frac{Wx^3}{12} - \frac{WL^3}{48} \right]$$

715120 @ 13:00 CAE and Stress Analysis CMSK020044)

6.)



$$\sigma_x = \tau_{xy} \sin 2\theta$$

$$= 72 \times 10^6 \sin 94$$

$$= 71824611.62 \text{ N/m}^2$$

$$= 71.82 \text{ MN/m}^2$$

$$c.) \quad \tau_x = -\tau_{xy} \cos 2\theta$$

$$= -72 \times 10^6 \cos 94$$

$$= 5022466.11 \text{ N/m}^2$$

$$= 5.02 \text{ MN/m}^2$$

d.) Bolts in a bus seat, the threads hold in by shear stress, as seat tilts under deceleration. Theoretically the bolts would be held by shear stress alone.

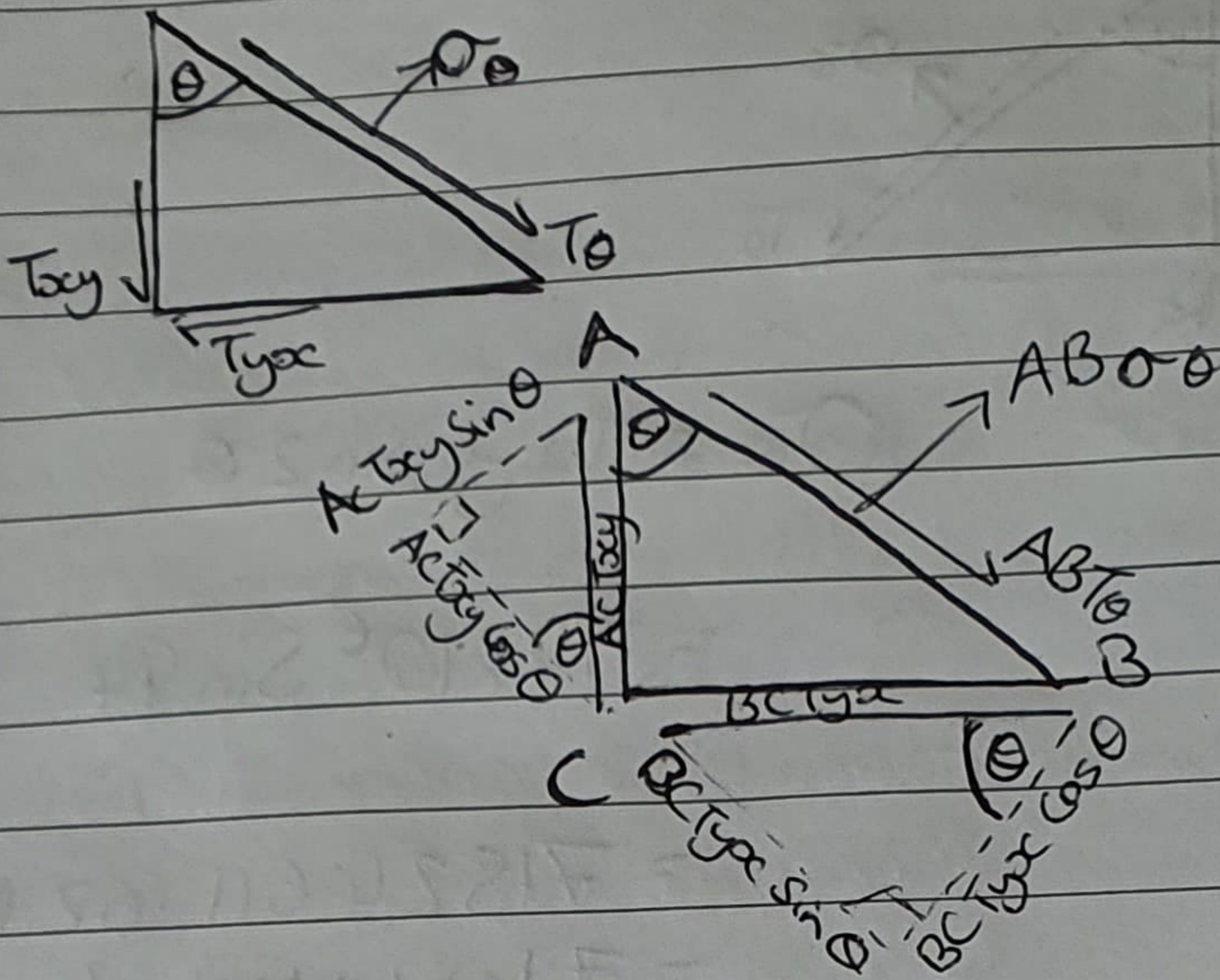
e.) Bolt precision and threading not always perfect, nor the taper holes, as such some axial stress may be applied.

7/5/20 @ 13:00 CAE and Stress Analysis (MSX02064)

2b) ~~con.~~ The design will remain focused on solving the problem at hand. It allows issues to be worked through in the earlier stages instead of being caught later.

7/5/20 @ 13:00 - CAE and Stress Analysis CMSX 020643

Q4.) a.)



For Equilibrium:

 $\sum \text{Forces } \perp \text{ to } AB = 0$

$$\therefore AB \sigma_\theta = AC T_{xy} \sin \theta + BC T_{yx} \cos \theta$$

$$\sigma_\theta = \frac{AC}{AB} T_{xy} \sin \theta + \frac{BC}{AB} T_{yx} \cos \theta$$

$$\frac{AC}{AB} = \cos \theta$$

$$\frac{BC}{AB} = \sin \theta$$

$$\begin{aligned} \therefore \sigma_\theta &= \cos \theta T_{xy} \sin \theta + \sin \theta T_{yx} \cos \theta \\ &= 2 T_{xy} \cos \theta \sin \theta \end{aligned}$$

$$\cos \theta \sin \theta = \frac{1}{2} \sin 2\theta$$

$$\therefore \sigma_\theta = T_{xy} \sin 2\theta$$

7/5/20 @ 13:00 - CAE and Stress Analysis (MSK02064)

that could be considered relevant to a specific set of controlled variables as they are at that value.

In real life these variables may not be as easy to control or quick to calculate. As such some variances can be expected.

e) The slope of the beam should also be considered

7/5/20 @ 13:00 - CAE and Stress Analysis CMSX020640

3c.) continued...

$$y_{\max} = \frac{-WL^3}{48EI}$$

$$\therefore y_{\max}(48EI) = -WL^3$$

$$\frac{y_{\max} 48EI}{-W} = L^3$$

$$L = \sqrt[3]{\frac{y_{\max} 48EI}{-W}}$$

$$\therefore$$

$$L = \sqrt[3]{\frac{0.01 \times 48 \times 217 \times 10^9 \times 62 \times 10^{-6}}{-50}}$$

$$L = -50.55 \text{ m}$$

* Check

$$y_{\max} = \frac{-WL^3}{48EI}$$

$$= \frac{-50 \times 50.55^3}{48 \times 217 \times 10^9 \times 62 \times 10^{-6}}$$

$$= 0.01 \text{ m}$$

d.) There are several variables that may cause the results in this question to ~~be~~ differ from a real life analysis. In real life some of these variables are not only open to change, but expected to. For example the load may vary regularly and vastly dependent on factors such as the number of passengers aboard the cabin, or the type of ~~values~~ cargo being transported etc...

The results as presented, only produce results

3 b.) $y_{\max}$ occurs when $x = 0$

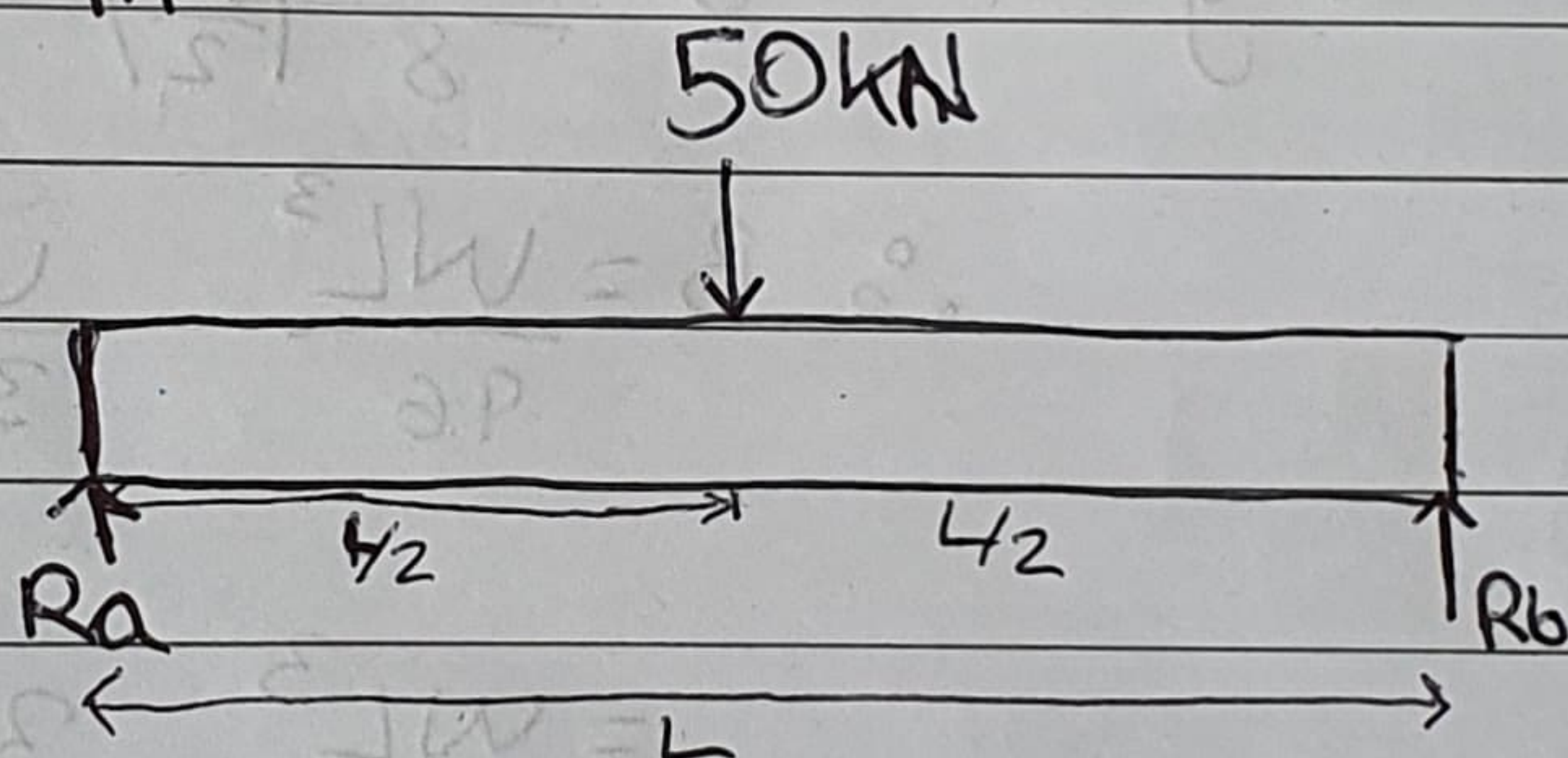
$$\therefore y = \frac{1}{EI} \left[\frac{WLx^2}{8} - \frac{Wx^3}{12} - \frac{WL^3}{48} \right]$$

Since $x = 0$

$$y = \frac{1}{EI} \left[\frac{WL(0)^2}{8} - \frac{W(0)^3}{12} - \frac{WL^3}{48} \right]$$

$$\therefore y_{\max} = \frac{1}{EI} \left[-\frac{WL^3}{48} \right]$$

$$= \frac{-WL^3}{48EI}$$

c.) $W = 50 \text{ kN}$ $A = 0$ $y_{\max} = 0.01 \text{ m}$ $E = 217 \text{ GPa}$ $I = 62 \times 10^{-6} \text{ m}^4$ 

$$M_{xx} = \frac{WL}{4} - \frac{Wx}{2} = EI \frac{d^2y}{dx^2}$$

$$y = \frac{1}{EI} \left[\frac{WLx^2}{8} - \frac{Wx^3}{12} - \frac{WL^3}{48} \right]$$

 $y_{\max}$ is at $x = 0 \therefore$

$$y_{\max} = \frac{1}{EI} \left[-\frac{WL^3}{48} \right] = \frac{-WL^3}{48EI}$$

7/5/20 @ 13:00 CAE and Stress Analysis (MSK02064)

Q2.) The ~~processes~~^{tasks} of the design process are discussed below:

Task A - Define the problem.

A clear definition of the problem or hand should be produced and should include:-

- i) customer's needs: i.e. what problem is the product attempting to solve.
- ii) problem statement:- should be broad, encompassing potential solutions to the problem whilst addressing the specific need identified.
- iii) established criteria for ~~success~~^{success}, this will involve ~~the~~^{various} members of workforce e.g. managers, engineers, marketing etc...

Task B - Gather Relevant Information.

Questions that may be asked in this stage include:

- i.) is the problem real?
- ii.) is there a need for a new solution?
- iii.) are there existing solutions?
- iv.) ~~iii~~ what is wrong with the current solutions?
- v.) Who produces the current solution?
- vi.) What are customers likely to pay for these solutions?
- vii.) economic impacts
- viii.) what other factors need to be considered.
~~Health and safety etc...~~

Task C - Generate Multiple Solutions

- This phase involves more of the creative sub tasks; these may include:-

- i.) Brainstorming, C team should be free to vote ask
- ii) 'synthesis' of new ideas toward solving design issues

7/5/20 @ 13:00 CAE and Stress Analysis (MSX02064)

Q2a) continued...

Task D involves Analysis and Solution, at this phase various forms of Analysis should be considered.

~~These include:~~ Functional Analysis,
~~these include examples such as:~~ Industrial design / ergonomics
Mechanical Analysis
Electromagnetic Analysis
Manufacturability
Product safety and reliability

Task E is the ~~Testing~~ phase.

At this stage, prototyping and testing under real conditions should be carried out. This can be used to evidence the findings of the Analytical data presented during task D.

Legislative Documentation should be prepared if necessary, and any patents applied for.

Q.2.b.) I believe ~~all~~ of these steps would benefit from FEA. The ~~the~~ use of FEA throughout the process allows for efficient production of designs for solutions ~~to~~ to the problem.

~~It allows design errors to be fixed sooner.~~
It allows the design process to exclude easily any designs that are likely to fail, and produce the best results in the shortest time.

By integrating FEA into all aspects, as early as brain storming,