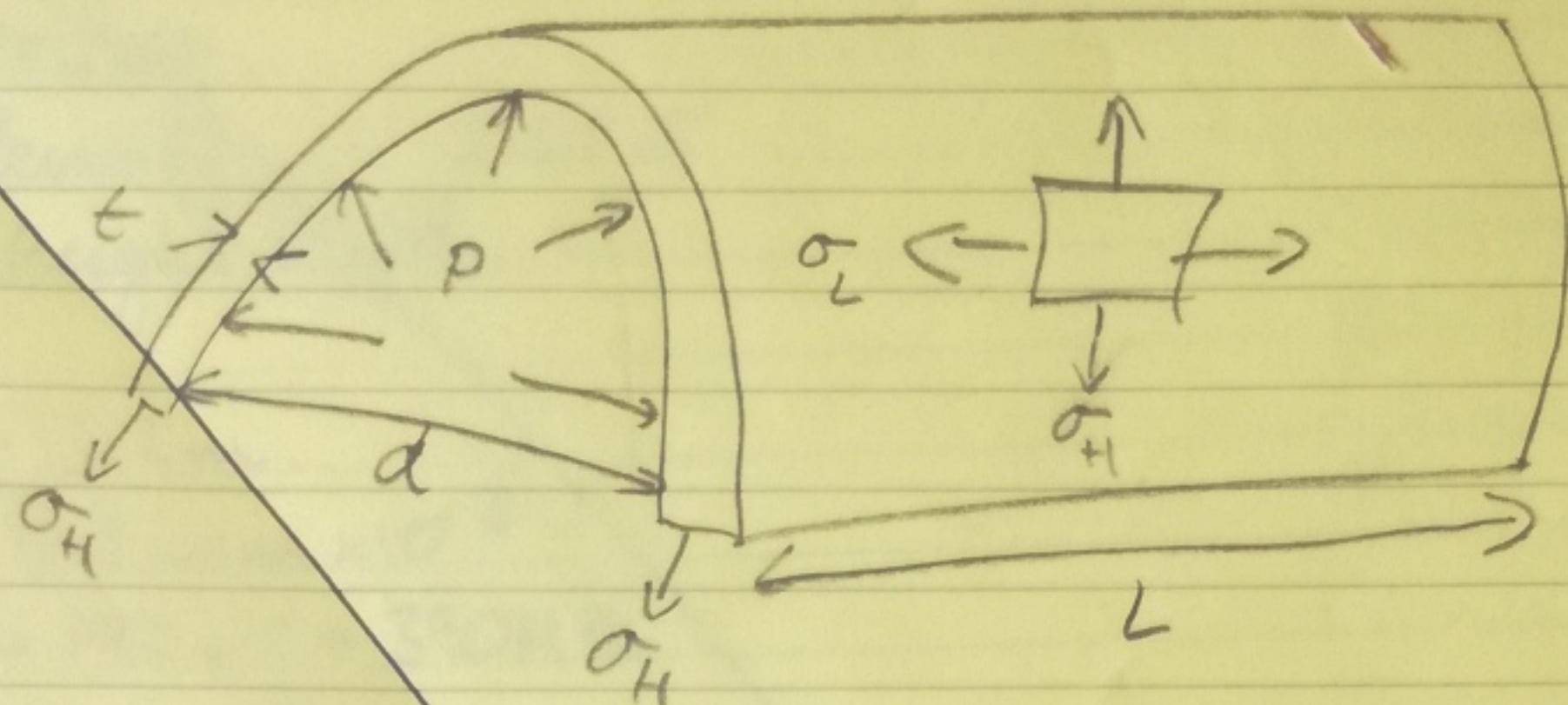


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Qn 1/a)



Force on half cylinder
= pressure $\times$ projected area = pdl

Resisting force
= $2\sigma_H \times Lt$

$$\therefore 2\sigma_H Lt = pdl$$

$$\therefore \boxed{\sigma_H = \frac{pd}{2t}}$$

b) hoop/circumferential stress is twice the longitudinal stress

c) 34.5 psu @ 15°C 1.0255 g/cm³

$$\text{kg/m}^3 \rightarrow \times 1000 = 1025.5 \text{ kg/m}^3$$

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d) $P = \rho g h$

P = Pressure

ρ = density = 1025.5

h = height / depth = ?

$$d = 3.2 \text{ m}$$

$$t = 3.2 \text{ mm} \times 10^{-3}$$

$$\sigma_H = 195 \times 2 = 390 \text{ MPa}$$

$$\sigma_H = \frac{P d}{2 t}$$

↑ Safety factor

$$\frac{\sigma_H 2 t}{d} = P = \frac{390 \times 10^6 \times 2 \times 3.2 \times 10^{-3}}{3.2} = 780000$$
$$= 780 \text{ kPa}$$

$$\frac{P}{\rho g} = h$$

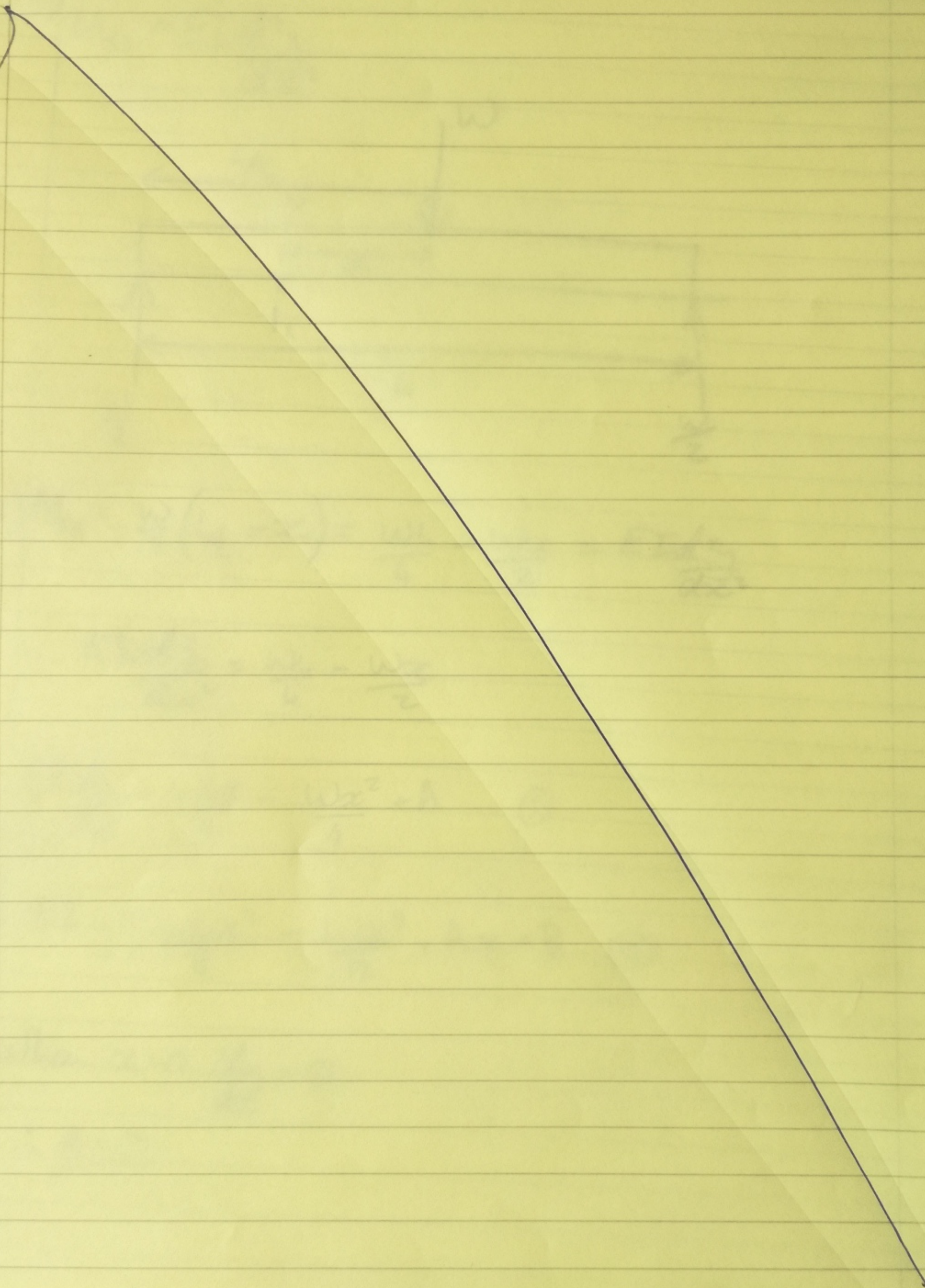
$$\frac{780 \times 10^3}{1025.5 \times 9.81} = \underline{77.53 \text{ m}}$$

e)

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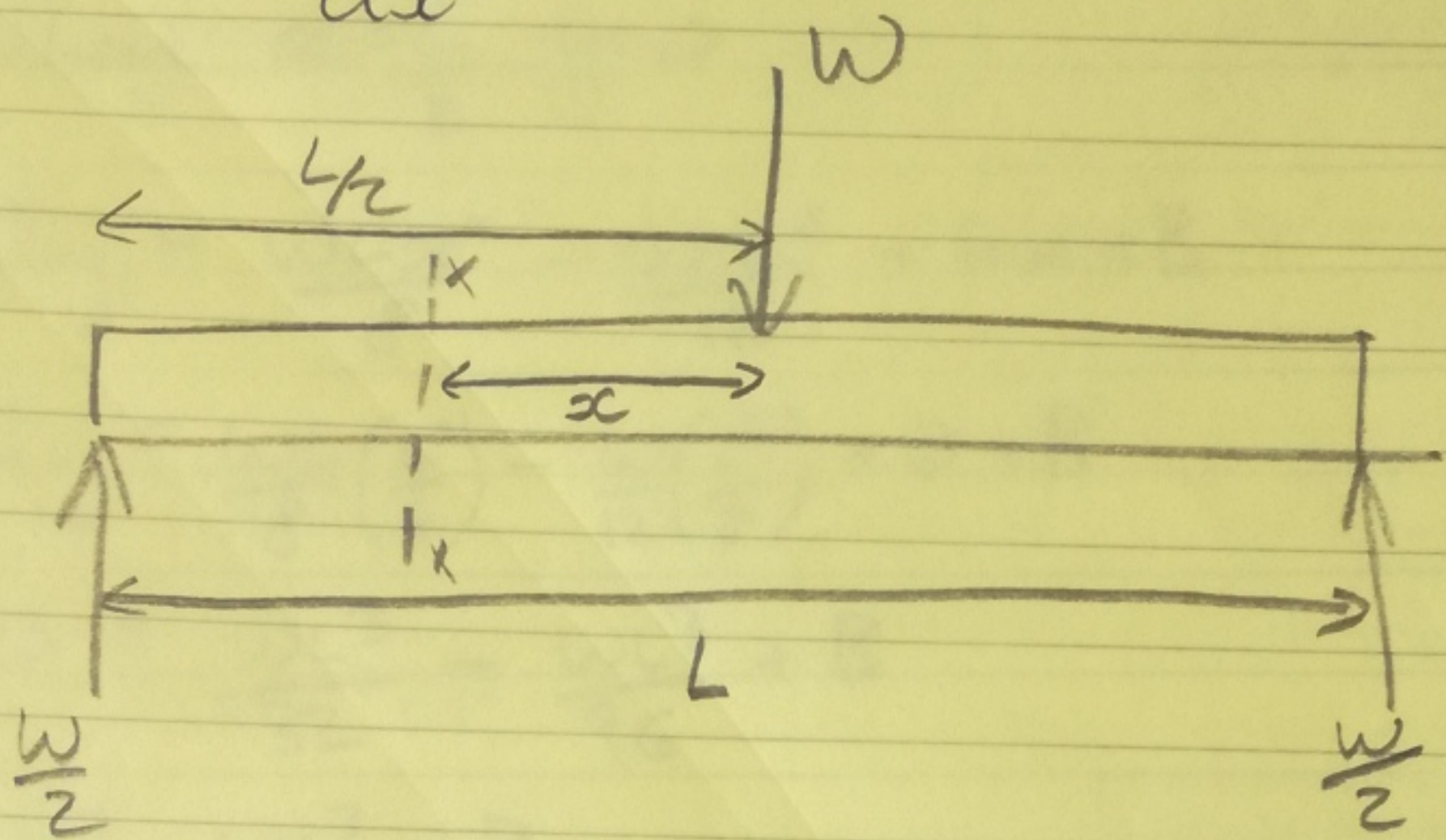
f)



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



a) $M_{xx} = \frac{W}{2} \left(\frac{L}{2} - x \right) = \frac{WL}{4} - \frac{Wx}{2} = EI \frac{d^2 y}{dx^2}$

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

Slope $EI \frac{dy}{dx} = \frac{WLx}{4} - \frac{Wx^2}{4} + A$ (1)

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

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

$\therefore A = 0$

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3a) using (2)

When $x = \frac{L}{2}$ $y = 0$

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

$$EIy = \frac{WL\left(\frac{L^2}{4}\right)}{8} - \frac{W\left(\frac{L^3}{8}\right)}{12} + 0 + B$$

$$0 = \frac{WL^3}{32} - \frac{WL^3}{96} + B$$

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

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

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

$$\boxed{-\frac{WL^3}{48} = B}$$

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

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

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

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

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

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

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

C) $W = 55 \text{ kN}$
 $E = 211 \text{ GPa}$
 $I = 56 \times 10^{-6} \text{ m}^4$
 $L = ?$

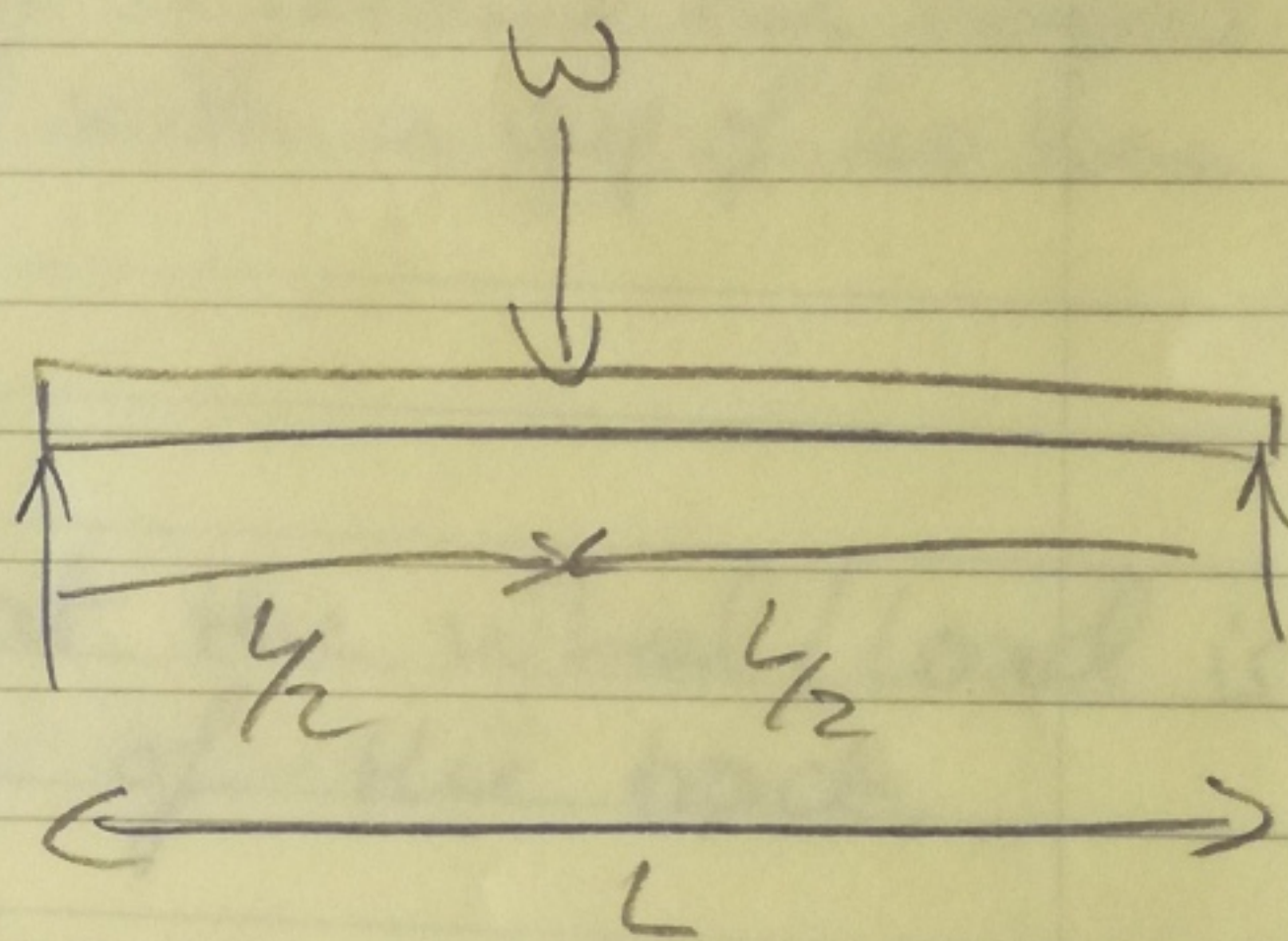
$$y_{\max} = -9.5 \text{ mm} \times 10^{-3}$$

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

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

$$\sqrt[3]{\frac{-9.5 \times 10^{-3} \times 48 \times (211 \times 10^9 \times 56 \times 10^{-6})}{-55 \times 10^3}} = L$$

$$4.61 \text{ m} = L$$



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3d) the results in part c) would differ to the real scenario because the wheels on trains tend to be mounted in pairs, which would change the loading on the beam (track). The lengths of track are also supported along their length ~~of the track~~ with sleepers, also changing the scenario, this is because the sleepers are typically evenly spaced with a gap of less than 4m.

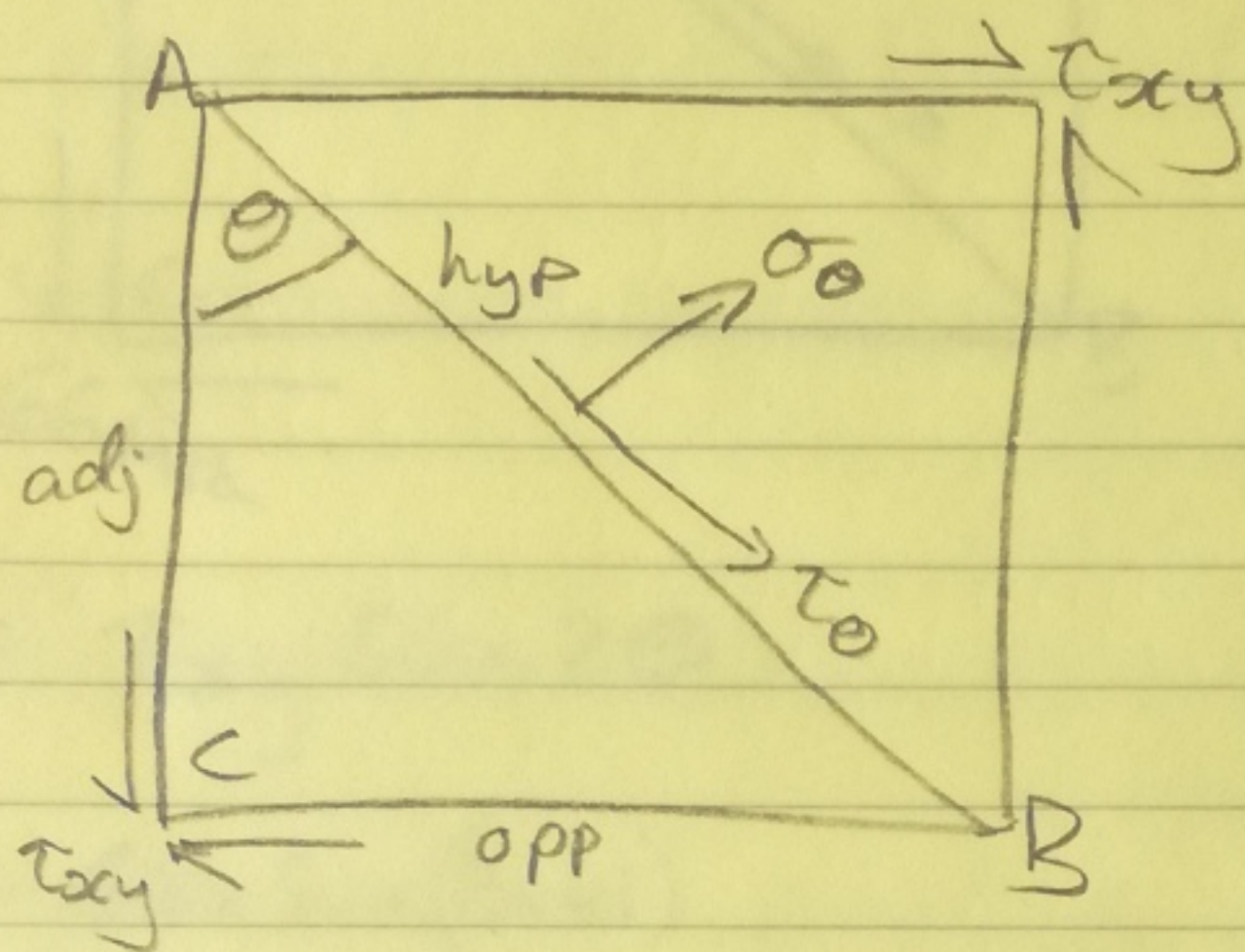
e) one should consider that the wheel/load is moving along the length of the track.

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4) a) $\cos\theta \sin\theta = \frac{1}{2} \sin 2\theta$

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



Σ of Force perpendicular to AB are 0.

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

$$C^A \quad H \quad S^O \quad H \quad T^O \quad A$$

$$\frac{AC}{AB} = \frac{\text{adj}}{\text{hyp}} = \cos\theta \quad \frac{BC}{AB} = \frac{\text{opp}}{\text{hyp}} = \sin\theta$$

$$\sigma_\theta = \tau_{xy}\sin\theta\cos\theta + \tau_{xy}\cos\theta\sin\theta$$

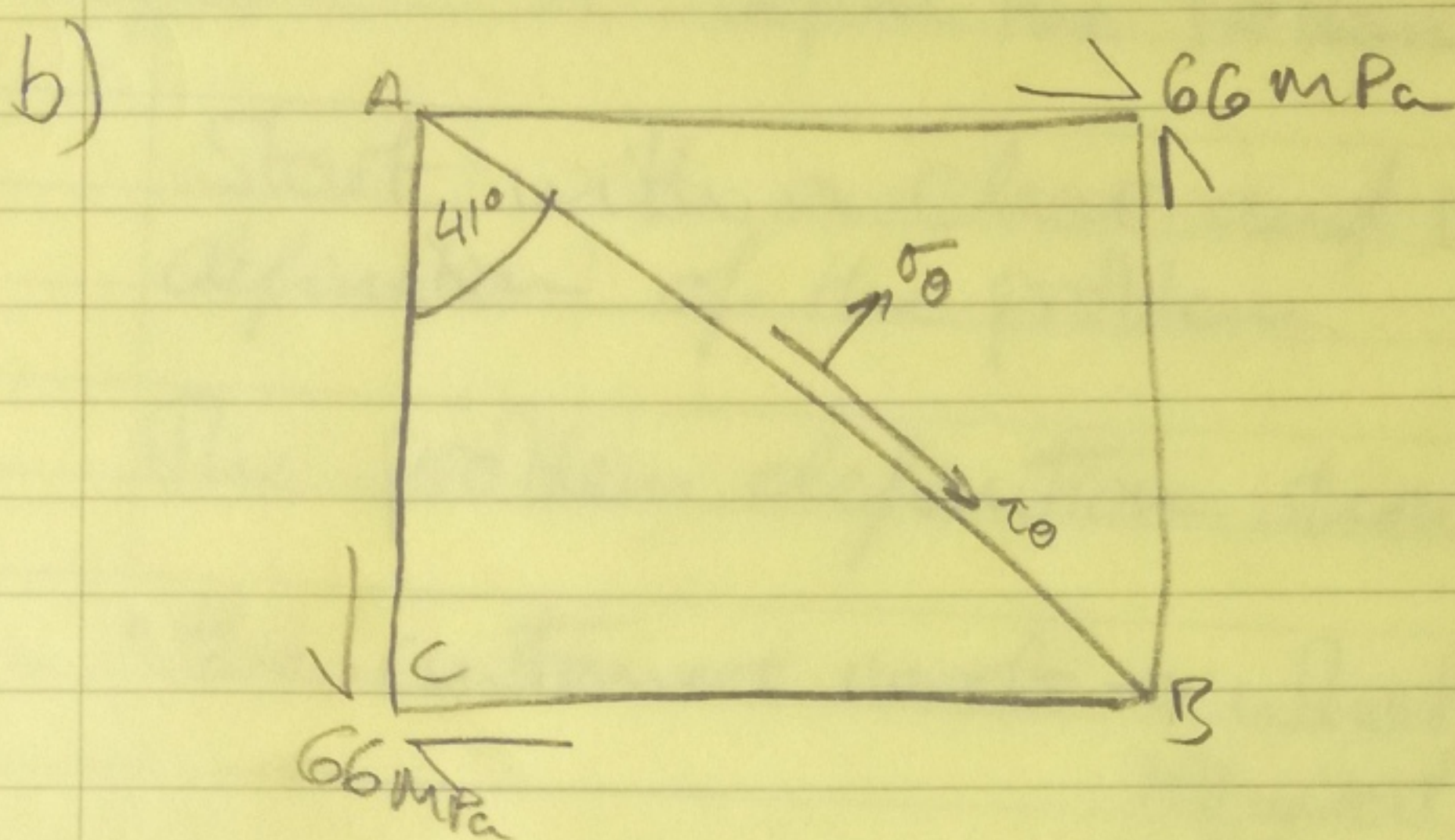
$$\sigma_\theta = 2\tau_{xy}\sin\theta\cos\theta$$

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

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

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$$\tau_{xy} = 66 \text{ MPa}$$

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

$$\sigma_{\theta} = 66 \times \sin(2 \times 41)$$
$$\sigma_{\theta} = 65.35 \text{ MPa}$$

X

c)

$$\tau_{\theta} = -\tau_{xy} \cos 2\theta$$
$$\tau_{\theta} = -66 \times \cos(2 \times 41)$$
$$\tau_{\theta} = -9.18 \text{ MPa}$$

X

d) a situation where a piece of material may be assumed to be subjected ~~to~~ to shear stress only could be when using scissors to cut paper, or tin snips to cut sheet metals. This ~~because~~ the operate with a shearing motion.

e) this is unlikely to happen because when using scissors/tin snips ones hands apply torsional force, resulting in an additional stress to consider.

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2) a) A = Define the Problem

Start with a clear and Unambiguous definition of the problem.

The problem definition should include:

- the customers needs $\rightarrow$ what is the product required to do? what problem is it solving?
- Develop problem statement $\rightarrow$ ~~broad but not so~~ this should be broad enough not to preclude possible solutions but will specifically address the need identified
- Criteria for success $\Rightarrow$ This will involve input from many roles from members of the team, such as managers, scientists, marketing etc.

B = Gather Relevant information

- is the problem real and ~~the~~ the statement accurate
- Is there really a need for a new solution or has the problem already been solved
- What are the existing solutions to the problem?

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- What's wrong with the current solution?
- What is right with the current solution?
- What companies manufacture the existing solution?
- What ergonomic factors govern the solution?
- How much will customers pay?

C = Generate Multiple solutions

- brainstorming,
- Synthesis of new ideas to solve design problem
- People of different discipline should be involved.

D = Analyse and select a solution

- Functional analysis
- Ergonomics - will it fit 95% of customers?
- Strength analysis - will it withstand the required 'abuse'

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• Product safety and reliability - is it safe to use and will it continue to work?

• Regulations and Standards - does it meet/exceed all the relevant regulations and standards?

E = Test and implement chosen solution

- Testing a prototype under real conditions
 - gain data to refine solution further?
 - documentation to prove testing has taken place.
- Apply for patents to protect the design.

2b) FEA ~~could~~ be used to reduce the overall design process duration, resulting in a reduce of cost, both labour and fixed costs.

FEA would benefit sections C, D and E as these will all need a form of testing to be carried out. It allows you to establish whether suggested solutions could be viable or not by subjecting CAD models with varying loads on an FEA program.