

7/5/20 13.00

Sam Williams

CAE and Stress Analysis
M5X02064

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a) Total force on half the cylinder due to the internal pressure
 $= p \times \text{projected area} = p d l$

The resisting force owing to hoop stress σ_H set up in the cylinder walls $= 2 \sigma_H \times L t$

$$\therefore 2 \sigma_H \times L t = p d l$$

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

b) The hoop stress is twice the longitudinal stress

c) Salinity is 33.5 psu
 $T = 0^\circ \text{C}$

$$1.0270 \text{ g/cm}^3 \times 1000 \\ = 1027 \text{ kg/m}^3$$

d) $P = \rho g h$ Thin cylinder $h = ?$

$$d = 5.8 \text{ m}$$

$$t = 0.0058 \text{ m}$$

Safety factor of 2.1

$$\text{Yield stress} = 200 \times 10^6 \text{ Pa} \times 2.1 = 420 \times 10^6 \text{ Pa}$$

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

$$p = \frac{2 t \sigma_H}{d} = \frac{2 \times 0.0058 \times 200 \times 10^6}{5.8} = 4000000 \text{ Pa}$$

$$h = \frac{p}{\rho g} = \frac{0.84 \times 10^6}{1027 \times 9.81} =$$

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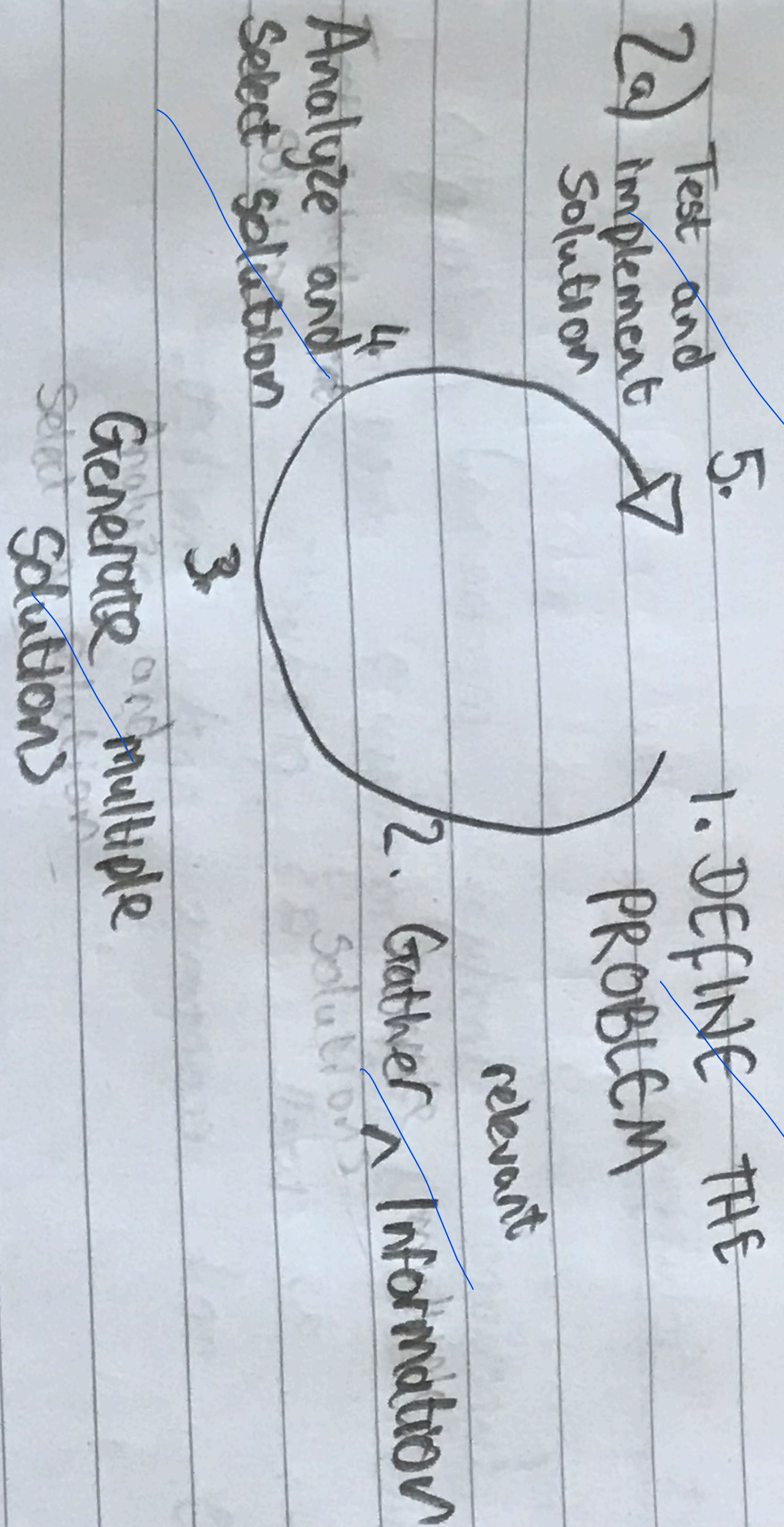
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1. Define the problem

The solution should begin with a clear, unambiguous definition of the problem. It should identify + establish customer needs and what problem it is solving. Should also develop a problem statement that is broad enough to preclude possible solutions and establish a criteria for success

relevant

2. Gather & information

Is the problem real and is statement accurate?
Is there a need for solution or has problem been solved? Are there existing solutions. Economics, aesthetics, ~~university~~, safety, environmental + sustainability

3. Generate multiple solutions

Creative phase that includes brainstorming and initial design. Deconstructing existing solutions. Design teams should be free to take risks and people of different disciplines should be involved.

4. Analyse and select Solution

At this stage functional analysis, mechanical / strength analysis and industrial design / ergonomics may be carried out, as well as product safety + reliability and economic and market analysis

5. Test and implement Solution

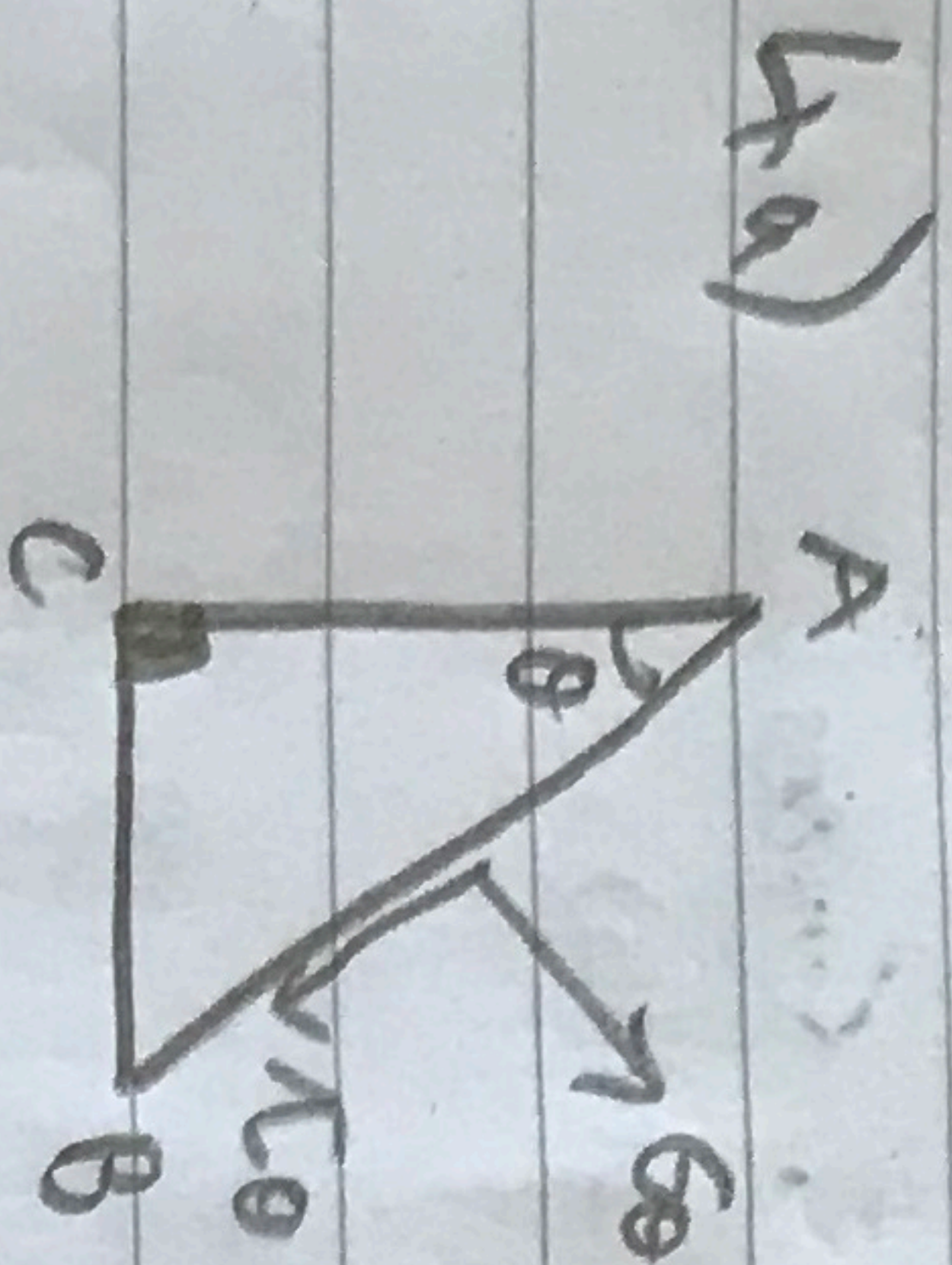
At this stage prototyping and testing under real conditions take place and be used to correlate analytical work from step 4 to gain confidence, legislative documentation may be required for audits and testing. Patents should be applied for to protect design.

2b) I feel that steps 2 and 3 could benefit from FEA being used as early as step 1 in defining the problem. Using FEA earlier in the design process can be used to reduce conceptual development times and lead to better designs. The amount of CAD in step 3 would be significantly reduced to the point where conceptual work can be done with no CAD. Models can be produced and verified in an FE environment. If CAD is used, designs are usually produced quicker and more efficient and for less cost as major leadpaths etc would have been introduced to the design due to early use of FEA

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The solutions and prototypes in steps 4 and 5 could be likely be improved standard $\therefore$ FEA can be beneficial to ~~many~~ many steps in the design process. Reduces



Σ Forces perpendicular to $AB = 0$

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

$$\frac{AC}{AB} = \cos \theta \quad \text{and} \quad \frac{BC}{AB} = \sin \theta$$

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

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

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

4b) $\sigma_{\theta} = 92 \times 10^6 \sin (2 \times 67)$

$$\sigma_{\theta} = 66.18 \text{ MPa}$$

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

$$= -92 \times 10^6 \cos (2 \times 67) = 63.91 \text{ MPa}$$

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d) Shear stress is a max on planes 45° to planes of principal stress. An example of shear stress only could be using scissors to cut paper.

e) ~~the~~ When using scissors, the cutting arms use shear stress caused by fingers moving in a rotational fashion around the pivot. Forces exerted make it unlikely to be shear stress only (compressional + torsional forces)

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3a) Max = $EI \frac{d^2y}{dx^2}$

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$$EI \frac{d^2y}{dx^2} = \frac{wL}{4} - \frac{wx}{2}$$

$$\textcircled{1} \quad EI \frac{dy}{dx} = \frac{wLx}{4} - \frac{wx^2}{4} + A$$

$$\textcircled{2} \quad EI y = \frac{wLx^2}{8} - \frac{wx^3}{12} + Ax + B$$

When $x=0$, $\frac{dy}{dx} = 0$ $\therefore A = 0$ (from $\textcircled{1}$)

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

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

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

$$B = -\frac{wL^3}{48}$$

$$\therefore y = \frac{1}{EI} \left[\frac{wLx^2}{8} - \frac{wx^3}{12} - \frac{wL^3}{48} \right]$$

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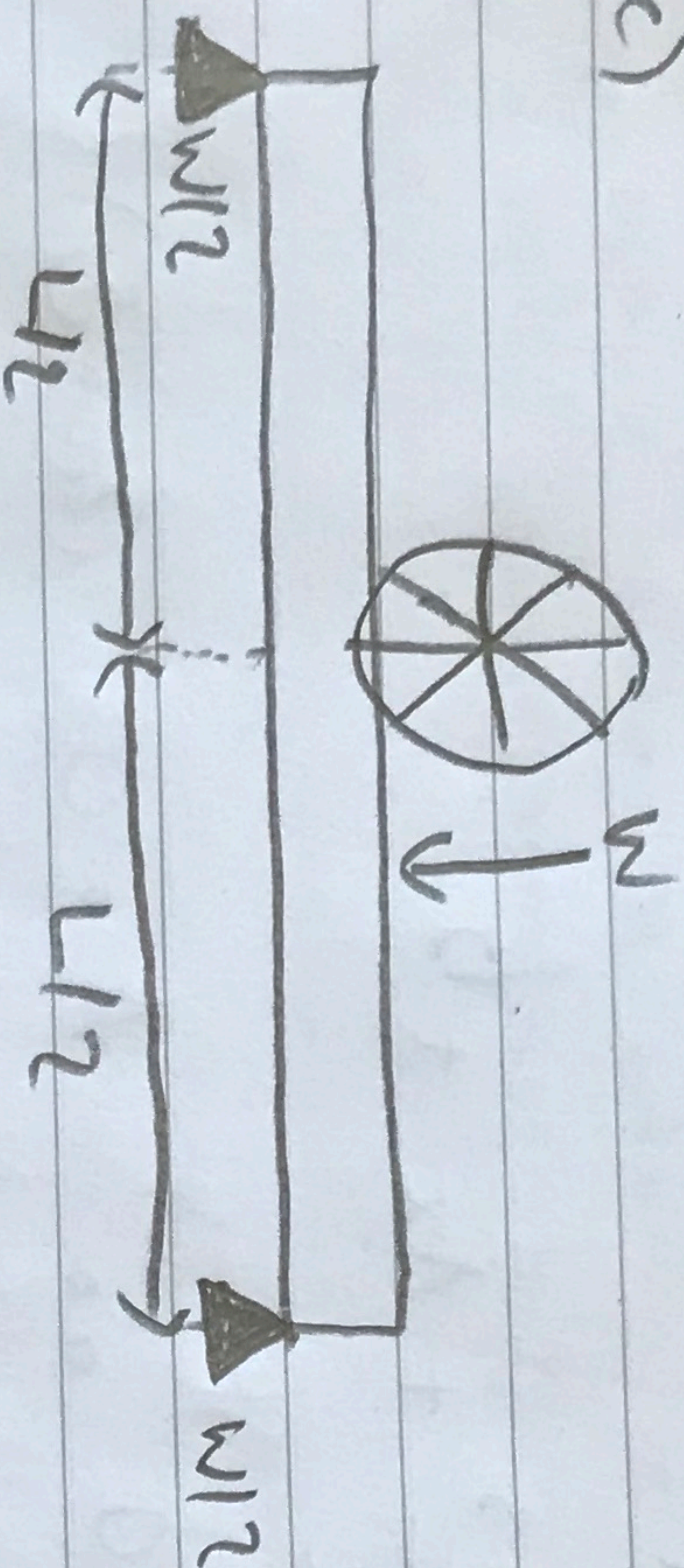
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b) When $x = 0$, $y = \max$

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

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

c)



$$y_{\max} = 0.011 \text{ m}$$

$$w = 48 \times 10^3 \text{ N}$$

$$E = 237 \times 10^9 \text{ Pa}$$

$$I = 82 \times 10^{-6} \text{ m}^4$$

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

$$L = \sqrt[3]{\frac{(48 \times 237 \times 10^9 \times 82 \times 10^{-6}) (0.011)}{-48 \times 10^3}} = 5.98 \text{ m}$$

d) Train wheels are rarely fitted singularly and this would affect the loading on the beam. The sleepers are usually mounted closer than approx 6m apart. Sleepers support the track and help to dissipate the load. Passengers and luggage vary and would also affect loadings

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e) It should be considered that the load would be distributed along the complete length, L , of track and supports