



12 Pages

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2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
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8. **Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.**

Smith

FORENAME(S):

James

[illegible]

Mark Agreed

(Gweler yr ochr arall am y fersiwn Cymraeg)

56%



1)

$$\epsilon_x = -12 \times 10^{-6} (\epsilon_1)$$

$$\epsilon_y = +16 \times 10^{-6} (\epsilon_2)$$

$$\nu = 0.25$$

$$E = 163 \text{ GPa } (163 \times 10^9 \text{ Pa})$$

i)

$$\sigma_1 = \frac{E}{1-\nu^2} (\epsilon_1 + \nu \epsilon_2) \checkmark$$

$$\sigma_1 = \frac{163 \times 10^9}{1-0.25^2} (-12 \times 10^{-6} + (0.25 \times 16 \times 10^{-6})) \checkmark$$

$$\sigma_1 = 1.39 \times 10^6 \text{ Pa or } 1.39 \text{ MPa (Tensile)}$$

$$\sigma_2 = \frac{E}{1-\nu^2} (\epsilon_2 + \nu \epsilon_1)$$

$$\sigma_2 = \frac{163 \times 10^9}{1-0.25^2} (16 \times 10^{-6} + (0.25 \times -12 \times 10^{-6})) \checkmark$$

$$\sigma_2 = 2.26 \times 10^6 \text{ Pa or } 2.26 \text{ MPa (Tensile)}$$

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ii)

$$\sigma_x = 25 \text{ MPa } (25 \times 10^6 \text{ Pa}) (\sigma_1)$$

$$\sigma_y = -20 \text{ MPa } (-20 \times 10^6 \text{ Pa}) (\sigma_2)$$

$$\epsilon_1 = \frac{1}{E} (\sigma_1 - \nu \sigma_2) \checkmark$$

$$\epsilon_1 = \frac{1}{163 \times 10^9} (25 \times 10^6 - (0.25 \times -20 \times 10^6)) \checkmark$$

$$\epsilon_1 = 184.05 \times 10^{-6} \text{ (no units)} \checkmark$$

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$$\epsilon_2 = \frac{1}{E} (\sigma_2 - \nu \sigma_1)$$

$$\epsilon_2 = \frac{1}{163 \times 10^9} (-20 \times 10^6 - (0.25 \times 25 \times 10^6)) \checkmark$$

$$\epsilon_2 = -161.04 \times 10^{-6} \text{ (no units)} \checkmark$$

2)

$$L = 300 \text{ mm } (0.3 \text{ m})$$

$$P = 55 \text{ MPa } (55 \times 10^6 \text{ Pa})$$

$$E = 163.2 \text{ GPa } (163.2 \times 10^9 \text{ Pa})$$

$$\nu = 0.3$$

$$\begin{aligned} \text{i)} \quad K &= \frac{E}{3(1-2\nu)} \\ K &= \frac{163.2 \times 10^9}{3(1-2 \times 0.3)} \\ K &= 1.36 \times 10^{11} \text{ Pa} \end{aligned}$$

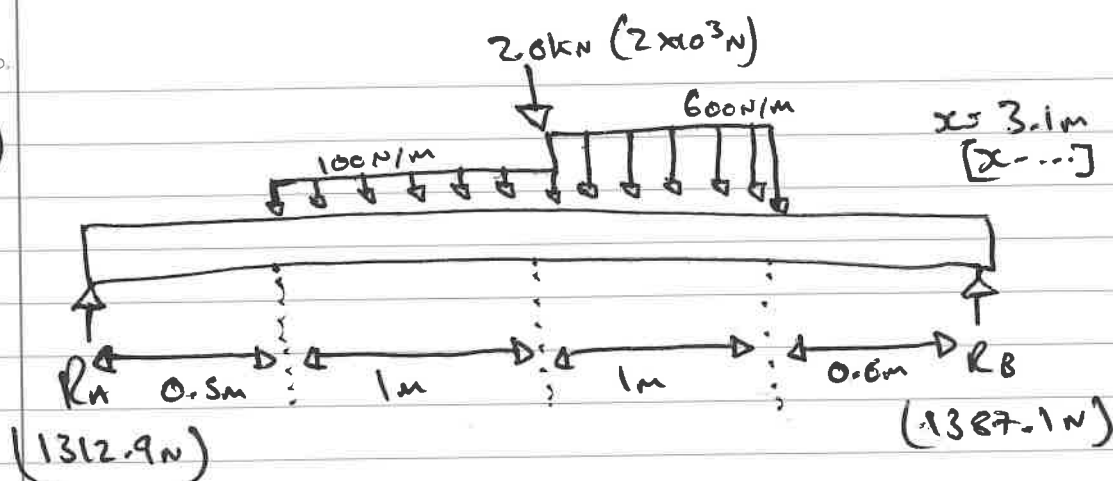
$$\begin{aligned} \text{ii)} \quad K &= \frac{\sigma}{\epsilon_v} = \frac{-P}{\epsilon_v} \\ K &= \frac{-P}{\epsilon_v} \\ \epsilon_v &= \frac{-P}{K} \\ \epsilon_v &= \frac{-55 \times 10^6}{1.36 \times 10^{11}} \\ \epsilon_v &= -404.41 \times 10^{-6} \text{ (no units)} \end{aligned}$$

$$\text{iii)} \quad 0.3^3 = 0.027 \text{ m}^3$$

$$\begin{aligned} \epsilon_v &= \frac{\Delta V}{V} \\ \Delta V &= \epsilon_v \times V \\ \Delta V &= -404.41 \times 10^{-6} \times 0.027 \\ \Delta V &= -10.92 \times 10^{-6} \text{ m}^3 \end{aligned}$$

iv) Orthotropic material is a material that exhibits expected behaviour, an example of this is steel.

3)



Bending moment i)

$$EI \frac{d^2y}{dx^2} = 1312.9[x] - \frac{100[0.5]^2}{2} + \frac{100[1.5]^2}{2} - 2 \times 10^3(1.5) - \frac{600[1.5]^2}{2} + \frac{600[2.5]^2}{2}$$

Slope ii)

$$EI \frac{dy}{dx} = \frac{1312.9[x]^2}{2} - \frac{100[x-0.5]^3}{6} + \frac{100[x-1.5]^3}{6} - \frac{2 \times 10^3[x-1.5]^2}{2} - \frac{600[x-1.5]^3}{6} + \frac{600[x-2.5]^3}{6} + C_1$$

Deflection iii)

$$EI y = \frac{1312.9[x]^3}{6} - \frac{100[x-0.5]^4}{24} + \frac{100[x-1.5]^4}{24} - \frac{2 \times 10^3[x-1.5]^3}{6} - \frac{600[x-1.5]^4}{24} + \frac{600[x-2.5]^4}{24} + C_1 x + C_2$$

iv) ($x = 3.1$ and $y = 0$)

$$EI(0) = 6.52 \times 10^3 - 190.41 + 27.31 - 1.37 \times 10^3 - 163.84 + 3.24$$

3)

$$v) EI = 1.00 \text{ MPa} (1 \times 10^6 \text{ Pa})$$

$$\frac{\text{Point load}}{48EI} = \frac{(2 \times 10^3)^3}{48(1 \times 10^6)} = \underline{166.67}$$

Not
Standard
Case

$$\frac{\text{UDL one}}{384EI} = \frac{5 \times 100 \times 1^4}{384 \times (1 \times 10^6)} = \underline{1.3 \times 10^{-6}}$$

X

$$\frac{\text{UDL Two}}{384EI} = \frac{5 \times 600 \times 1^4}{384 \times (1 \times 10^6)} = \underline{7.81 \times 10^{-6}} \quad \times$$

$$\text{Deflection at Centre of Beam} = \underline{166.67}$$

4)

$D = 280 \text{ mm} \quad (0.28 \text{ m})$
 $L = 600 \text{ mm} \quad (0.6 \text{ m})$
 $P = 14.6 \text{ Bar} \quad (1.46 \times 10^6 \text{ N/m}^2)$
 $\sigma_{\text{MAX}} = 150 \text{ MPa} \quad (150 \times 10^6 \text{ Pa})$
 $\eta_L = 55\% \quad (0.55)$
 $\eta_c = 65\% \quad (0.65)$

1

i)

$$\sigma_c \neq \frac{PD}{2t\eta_L}$$
$$t \neq \frac{1.46 \times 10^6 \times 0.28}{150 \times 10^6 \times 2 \times 0.55}$$
$$t \neq 2.48 \times 10^{-3} \text{ m}$$
$$\sigma \times 2t\eta_L = P \times D$$
$$t = \frac{P \times D}{\sigma \times 2\eta_L}$$

Minimum Thickness = $2.48 \times 10^{-3} \text{ m}$

4

ii)

$$\sigma_L \neq \frac{PD}{4t\eta_c}$$
$$t \neq \frac{1.46 \times 10^6 \times 0.28}{4 \times 150 \times 10^6 \times 2 \times 0.65}$$
$$t \neq 2.09 \times 10^{-3} \text{ m}$$
$$\sigma \times 4t\eta_c = PD$$
$$t = \frac{P \times D}{\sigma \times 4\eta_c}$$

Minimum Thickness = $2.09 \times 10^{-3} \text{ m}$

2

iii) The minimum thickness allowed is $2.09 \times 10^{-3} \text{ m}$.

5)

$$ED = 48 \text{ mm} \quad (0.048 \text{ m})$$

$$ID = 38 \text{ mm} \quad (0.038 \text{ m})$$

$$P = 145 \text{ Bar}$$

$$145 \times 10^5 = 14.5 \times 10^6 \text{ N/m}^2$$

A)

$$\text{Boundary condition} = P_{\text{max}} = 48 \text{ mm} \quad D_{\text{min}} = 38 \text{ mm}$$