



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.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
8. **Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.**

FORENAME(S): Alex

[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)

Mark Freed
Kurt.

1.

$$\epsilon_x = -12 \times 10^{-6} \quad (-12 \mu\epsilon)$$

$$\epsilon_y = 16 \times 10^{-6} \quad (16 \mu\epsilon)$$

$$\nu = 0.25$$

$$E = 163 \text{ GPa} \quad (163 \times 10^9 \text{ N/m}^2)$$

i) $\sigma_x = ?$

$\sigma_y = ?$

$$\sigma_x = \frac{E}{1-\nu^2} (\epsilon_x + \nu \epsilon_y)$$

$$\sigma_y = \frac{E}{1-\nu^2} (\epsilon_y + \nu \epsilon_x)$$

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

$$\sigma_y = 2.26 \times 10^6 \text{ N/m}^2 \quad (2.26 \text{ MPa}) \quad \checkmark$$

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

$$\sigma_x = -1.39 \times 10^6 \text{ N/m}^2 \quad (-1.39 \text{ MPa}) \quad \checkmark$$

$$\sigma_y = \text{Tensile}$$

$$\sigma_x = \text{Compressive}$$

ii) $\sigma_x = 25 \text{ MPa}$ ($25 \times 10^6 \text{ N/m}^2$)
~~25 MPa~~ ~~25 MPa~~ ~~25 MPa~~

$\sigma_y = -20 \text{ MPa}$ (~~25 MPa~~) ($-20 \times 10^6 \text{ N/m}^2$)

$\nu = 0.25$

$E = 163 \text{ GPa}$ ($163 \times 10^9 \text{ N/m}^2$)

$\epsilon_x = ?$

$\epsilon_y = ?$

Wrong
ES!

$\epsilon_x = \frac{1}{E} (\sigma_x - \nu \sigma_y)$

$\epsilon_y = \frac{1}{E} (\sigma_y - \nu \sigma_x)$

$\epsilon_x = \frac{1}{163 \times 10^9} (-1.39 \times 10^6 - 0.25 \times 2.26 \times 10^6)$

$\epsilon_x = -11.99 \times 10^{-6}$ ~~11.99~~ ($-11.99 \mu\epsilon$)

$\epsilon_y = \frac{1}{163 \times 10^9} (2.26 \times 10^6 - 0.25 \times -1.39 \times 10^6)$

$\epsilon_y = 15.99 \times 10^{-6}$ ~~15.99~~ ($15.99 \mu\epsilon$)

2. Cube = $(300 \times 300 \times 300 \text{ mm})$, $0.3 \times 0.3 \times 0.3 \text{ m}$
 $-P = 55 \text{ MPa}$ ($55 \times 10^6 \text{ N/m}^2$)

i) $E = 163.2 \text{ GPa}$ ($163.2 \times 10^9 \text{ N/m}^2$)

$\nu = 0.3$

$K = ?$

~~$K = \frac{E}{2(1+\nu)}$~~

$K = \frac{E}{3(1-2\nu)} = \frac{\sigma}{\epsilon_v}$ $K = \frac{2G(1+\nu)}{3(1-2\nu)}$

$K = \frac{163.2 \times 10^9}{3(1-2 \times 0.3)}$

$K = 136 \times 10^9 \text{ N/m}^2$ (136 GPa)

ii) $\epsilon_v = ?$ ~~$K = \frac{\sigma}{\epsilon_v}$~~ $\sigma = \frac{-P}{A}$

$\sigma = \frac{-55 \times 10^6}{(0.3 \times 0.3)} = -611.11 \times 10^6 \text{ N/m}^2$ (-611.11 MPa)

$K = \frac{\sigma}{\epsilon_v}$ Rearrange for ' ϵ_v ' $= \epsilon_v = \frac{\sigma}{K}$

$\epsilon_v = \frac{-611.11 \times 10^6}{136 \times 10^9}$ $\epsilon_v = -4.49 \times 10^{-3}$

iii) $\Delta V = ?$ $\epsilon_v = \frac{\Delta V}{V}$

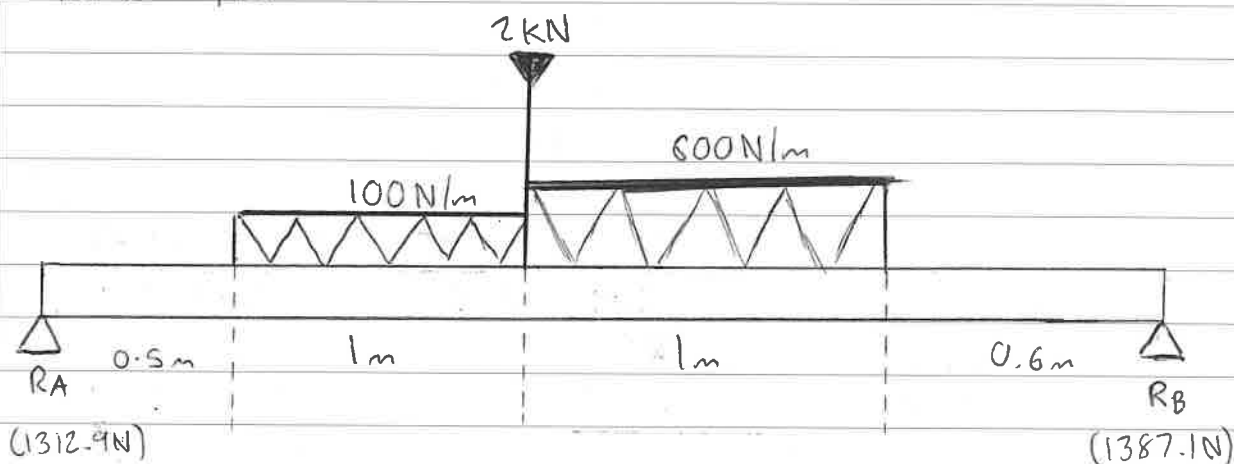
$V = (0.3 \times 0.3 \times 0.3)$, $0.3^3 = 27 \times 10^{-3} \text{ m}^3$

$\epsilon_v = \frac{\Delta V}{V}$ Rearrange for ' ΔV ' $= V \times \epsilon_v = \Delta V$

$27 \times 10^{-3} \times -4.49 \times 10^{-3} = -121.23 \times 10^{-6} \text{ m}^3$

- iv) An Orthotropic material is a material in which its physical reaction properties are different in each direction, such as wood for example.

3.



Eq 1

$$M = EI \frac{d^2 y}{dx^2} = +1312.9(x) - \frac{100(x-0.5)^2}{2} + \frac{100(x-1.5)^2}{2} - 2000(x-1.5) - \frac{600(x-1.5)^2}{2} + \frac{600(x-2.5)^2}{2}$$

Eq 2

$$EI \frac{dy}{dx} = \frac{+1312.9(x)^2}{2} - \frac{100(x-0.5)^3}{6} + \frac{100(x-1.5)^3}{6} - \frac{2000(x-1.5)^2}{2} - \frac{600(x-1.5)^3}{6} + \frac{600(x-2.5)^3}{6} + A$$

Eq 3

$$EI y = \frac{+1312.9(x)^3}{6} - \frac{100(x-0.5)^4}{24} + \frac{100(x-1.5)^4}{24} - \frac{2000(x-1.5)^3}{6} - \frac{600(x-1.5)^4}{24} + \frac{600(x-2.5)^4}{24} + A(x) + B$$

Boundary conditions = $x = 0 \quad y = 0$
 $x = -3.1 \quad y = 0$

Apply to Eq 3

$$EI y = \frac{+1312.9(-3.1)^3}{6} - \frac{100(-3.1-0.5)^4}{24} + \frac{100(-3.1-1.5)^4}{24} - \frac{2000(-3.1-1.5)^3}{6} - \frac{600(-3.1-1.5)^4}{24} + \frac{600(-3.1-2.5)^4}{24} + A(-3.1) + B$$

$$EI_y = \cancel{44181} - 6.52 \times 10^3 - 699.84 + 1.87 \times 10^3 + 32.45 \times 10^3 - 11.19 \times 10^3 + 24.59 \times 10^3 + A(-3.1) + B$$

$$EI_y = -6.52 \times 10^3 - 699.84 + 1.87 \times 10^3 + 32.45 \times 10^3 - 11.19 \times 10^3 + 24.59 \times 10^3 + 1312.9(-3.1) + 1387.1$$

$$EI_y = 40.50 \times 10^3 + 1312.9(-3.1) + 1387.1$$

$$EI_y = 37.82 \times 10^3$$

$$A = ?$$

$$B = ?$$

4. $D = 280 \text{ mm} \quad (0.28 \text{ m})$

$L = 600 \text{ mm} \quad (0.6 \text{ m})$

$n_L = 0.55$

$n_C = 0.65$ ✓

$P = 14.6 \text{ bar} \quad (14.6 \times 10^{-5} \text{ N/m}^2)$

$\sigma_{\max} = 150 \text{ MPa} \quad (150 \times 10^6 \text{ N/m}^2)$

11)

~~$\sigma_c = \frac{pD}{2t n_L}$~~

rearrange for 't'

~~$\sigma_c = \frac{pD}{2t n_L}$~~

$2 n_L \sigma_c = \frac{pD}{t}$

$\frac{2 n_L \sigma_c}{pD} = t$
X

~~$t = \frac{2 \times 0.55 \times 150 \times 10^6}{14.6 \times 10^{-5} \times 0.28}$~~

S. $d_o = 48 \text{ mm} (0.048 \text{ m})$
 $d_i = 38 \text{ mm} (0.038 \text{ m})$
 $P = 145 \text{ bar} (145 \times 10^5 \text{ N/m}^2)$

@ inner surface : $r = 0.019 \text{ m}$ ✓
 $P = 145 \times 10^5 \text{ N/m}^2$

$\sigma = ?$

2

@ outer surface : $r = 0.024 \text{ m}$
 $P = 0$ ✓

