



Complete, fold and seal
(see note 2 below)

SURNAME:

FORENAME(S):

1. Please give the information requested in the boxes below.
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.**

[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)

Mark Agreed
KML

51%

21. $\epsilon_x = -12 \times 10^{-6}$

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

$\nu = 0.25$

$E = 163 \text{ GPa} \rightarrow 163 \times 10^9$

$\sigma_x = ?$

$\sigma_y = ?$

Compressive ? or tensile ?

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

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

$\sigma_x = -1.39 \times 10^6$ $\rightarrow$ $\frac{1}{2}$ tensile compressive

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

$\sigma_y = 2.26 \times 10^6$ $\rightarrow$ $\frac{1}{2}$ compressive. tensile

ii) $\epsilon_x = \frac{1}{163 \times 10^9} (25 \times 10^6 - (0.25 \times -20 \times 10^6))$ ✓

$\epsilon_x = 154.04 \times 10^{-6} \rightarrow$ tensile

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

$\epsilon_y = -161.04 \times 10^{-6}$ compressive

Q2.

i) $L = 300 \text{ mm}$

$$P_o = 55 \text{ MPa} = 55 \times 10^6$$

$$E = 163.2 \text{ GPa} \rightarrow 163.2 \times 10^9$$

$$\nu = 0.3$$

$$K = ?$$

$$\sigma = \frac{P}{A}$$

$$A = 300^2 = 27 \times 10^{-3}$$

$$\sigma = -P$$

$$\sigma = \frac{55 \times 10^6}{27 \times 10^{-3}} = 2.04 \times 10^9 \text{ N/m}^2 \quad 2.04 \times 10^9 \text{ X}$$

$$K = \frac{\sigma}{\epsilon_{avg}}$$

$$K = \frac{E}{3(1-2\nu)}$$

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

$$K = \frac{163.2 \times 10^9}{3(1-(2 \times 0.3))} = 1.36 \times 10^{11} \text{ or } 136 \times 10^9 \quad 3$$

ii)

$$K = \frac{\sigma}{\epsilon_v}$$

$$\epsilon_v K = \sigma$$

$$\epsilon_v = \frac{\sigma}{K} = \frac{2.04 \times 10^9}{136 \times 10^9} = 0.015 \quad 1$$

iii)

$$\epsilon_x = \frac{1}{E} [204 \times 10^9 - 0.3 (204 \times 10^9 + 2.04 \times 10^9)]$$

$$\epsilon_x = 5.01 \times 10^{-3} = \epsilon_{x,y,z} \quad X$$

$$\epsilon_v = \frac{\Delta V}{V}$$

$$\nu \epsilon_v = \Delta V \quad \checkmark$$

$$27 \times 10^{-3} \times 0.015 = 4.05 \times 10^{-4} \quad 1$$

- iv) an orthotropic material is a material that has different elastic constant constants in different directions. ✓
 Rubber → when pulled at in the x axis the length in y decreases. X

Q3

$$i) \frac{d^2 y}{dx^2} = 1312.9 [x] - \frac{100(x-0.5)^2}{2} + \frac{100(x-1.5)^2}{2} -$$

$$2 \times 10^3 (x-1.5) - \frac{600(x-1.5)^2}{2} + \frac{600(x-2.5)^2}{2} \quad \checkmark \quad 2$$

$$\frac{dy}{dx} = \frac{1312.9 [x]^2}{2} - \frac{100(x-0.5)^3}{6} + \frac{100(x-1.5)^3}{6} -$$

$$\frac{2 \times 10^3 (x-1.5)^2}{2} - \frac{600(x-1.5)^3}{6} + \frac{600(x-2.5)^3}{6} + C \quad \checkmark \quad 2$$

$$y = \frac{1312.9 (x)^3}{6} - \frac{100(x-0.5)^4}{24} + \frac{100(x-1.5)^4}{24} -$$

$$\frac{2 \times 10^3 (x-1.5)^3}{6} - \frac{600(x-1.5)^4}{24} + \frac{600(x-2.5)^4}{24} + C_1 x + C_2 \quad \checkmark \quad 1$$

$$x=0 \quad y=0$$

$$x=3.1 \quad y=0$$

$$B=0$$

$$0 = 1312.9 \cdot 0 - 0 + 0 - 0 - 0 + 0$$

$$0 = \frac{1312.9 (3.1)^3}{6} - \frac{100(3.1-0.5)^4}{24} + \frac{100(3.1-1.5)^4}{24} -$$

$$\frac{2 \times 10^3 (3.1-1.5)^3}{6} - \frac{600(3.1-1.5)^4}{24} + \frac{600(3.1-2.5)^4}{24} + C(3.1)$$

$$\begin{aligned}
 & 6518.77 - 190.41 + 27.31 - 1365.3 \\
 & - 163.84 + 3.24 \\
 & = 4829.77
 \end{aligned}$$

Q4.

$$\phi = 20280 \text{ mm}$$

$$l = 6000 \text{ mm}$$

Speed

$$L = 55\%$$

$$C = 65\% \quad \times$$

$$P_i \text{ at } 14.6 \text{ Bar}$$

$$\max \sigma = 150 \text{ MPa}$$

$$t = ?$$

$$i) \quad \sigma_c = \frac{PD}{2 + R_L} \checkmark = \frac{14.6 \times 20280 \times 10^{-3}}{2}$$

$$\sigma = -P$$

$$t = \frac{PD}{2R_L \sigma_c} \checkmark = \frac{14.6 \times 10^6}{2 \times 55 \times -14.6 \times 10^6} \times$$

$$= -2.55 \times 10^{-3} \text{ m} \quad \text{min thickness}$$

$$ii) \quad \sigma_c = \frac{PD}{4 + R_L} \checkmark = + \frac{PD}{4R_L \sigma_L} \checkmark = -1.07 \times 10^{-3} \quad \times$$

$$iii) \quad 1.07 \times 10^{-3} \text{ or } -1.07 \times 10^{-3} \text{ min thickness.} \quad \times$$

Q5

$$\begin{aligned} o \phi &= 48 \text{ mm} \\ i \phi &= 38 \text{ mm} \\ P &= 145 \text{ Bar} \end{aligned}$$

$$\sigma = \frac{F}{A}$$

i) $\sigma = \frac{F}{\pi R^2}$

$$\sigma = \frac{145 \times 10^6}{\pi \times \frac{48^2 - 38^2}{24}} = 20.03 \times 10^9 \quad \frac{80.13 \times 10^9}{80.13 \times 10^9}$$

ii) $\sigma_{Ri} = a - \frac{b}{r^2}$ $\sigma_{Ro} = a - \frac{b}{r^2}$

$$142.45 \times 10^9 = a - \frac{b}{18^2}$$

$$20.03 \times 10^9 = a - \frac{b}{24^2}$$

$$142.45 \times 10^9 = a - \frac{b}{324}$$

$$80.13 \times 10^9 = a - \frac{b}{24^2}$$

$$80.13 \times 10^9 = a - \frac{b}{576}$$

x1

$$142.45 \times 10^9 = b - 324a$$

$$80.13 \times 10^9 = b - 576a$$

$$b = \frac{376a}{80.13 \times 10^9}$$

$$142.45 \times 10^9 = \frac{376a}{80.13 \times 10^9} - 324a$$

$$142.45 \times 10^9 \times 80.13 \times 10^9 = 376a - 324 \times a$$

$$\frac{142.45 \times 10^9 \times 80.13 \times 10^9}{376 + 324} = a = 16.31 \times 10^{18}$$

$$b = \frac{376 \times a}{80.13 \times 10^9} = \frac{376 \times 16.31 \times 10^{18}}{80.13 \times 10^9} = 7.65 \times 10^{10}$$

G

Question No.

Examiner On

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