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12 Pages

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.**

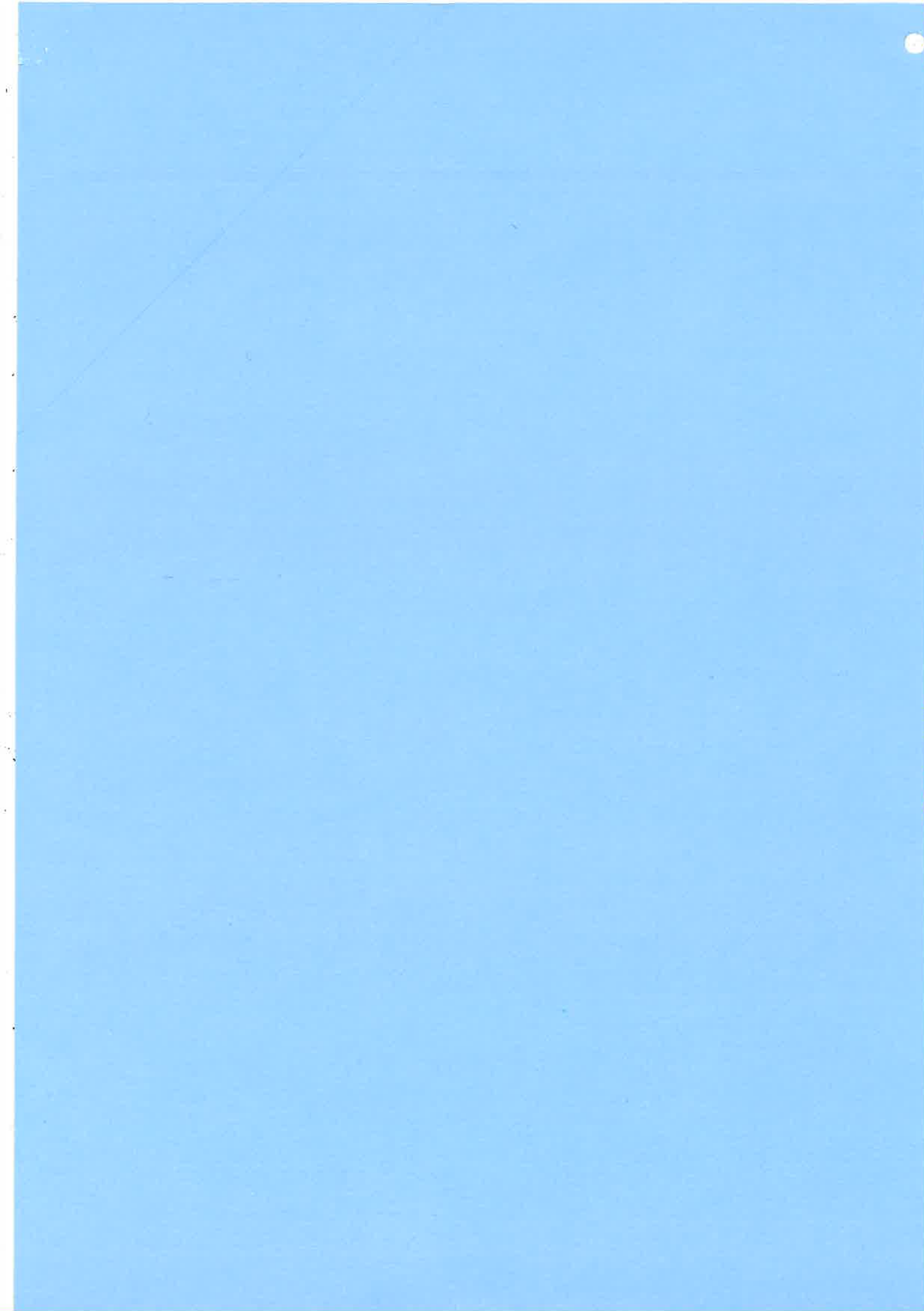
1	Student Number	P148408
2	Title of Examination Paper	Mechanical Principles
3	Module Code	MSX02201
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5	Examination Venue	1Q 301
6	Seat Number	G048
7	Number of Answer Books handed in	1

[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)

86%

Mark Agreed
K.H.



$\sigma = \text{Stress}$
 $\epsilon = \text{Strain}$ no units
 $K = \frac{F}{\epsilon V}$ Examiner Only

1 $\epsilon_x = -12 \times 10^{-6}$
 $\epsilon_y = 16 \times 10^{-6}$
 $\nu = 0.25$
 $E = 163 \times 10^9 \text{ Pa}$

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

$$\sigma_x = \frac{163 \times 10^9}{1-0.25^2} (-12 \times 10^{-6} + 0.25 \times 16 \times 10^{-6}) = \cancel{695.47 \times 10^3 \text{ Nm}^2} = \underline{-1.39 \times 10^6 \text{ Nm}^2}$$

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

$$\sigma_y = \frac{163 \times 10^9}{1-0.25^2} (16 \times 10^{-6} + 0.25 \times -12 \times 10^{-6}) = \cancel{-1.39 \times 10^6 \text{ Nm}^2} = 2.26 \times 10^6$$

$$\sigma_x = -1.39 \times 10^6 \text{ Nm}^2 \text{ (compressive)} \checkmark$$

$$\sigma_y = 2.26 \times 10^6 \text{ Nm}^2 \text{ Tensile.} \checkmark$$

$$1.ii \quad \sigma_x = 25 \times 10^6$$

$$\sigma_y = -20 \times 10^6$$

$$E = 163 \times 10^9$$

$$\nu = 0.25$$

$$\epsilon_x =$$

$$\epsilon_y =$$

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

$$\epsilon_x = \frac{1}{163 \times 10^9} (25 \times 10^6 - (0.25 \times -20 \times 10^6)) = 184.05 \times 10^{-6}$$

No units.

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

$$\epsilon_y = \frac{1}{163 \times 10^9} (-20 \times 10^6 - (0.25 \times 25 \times 10^6)) = -161.04 \times 10^{-6}$$

No units.

5

2.

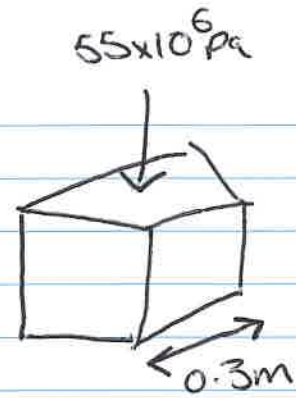
$$L = 0.3 \text{ m}$$

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

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

$$\nu = 0.3$$

$$K = ?$$



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

$$K = \frac{163.2 \times 10^9}{3(1-(2 \times 0.3))} = 136 \times 10^9 \text{ N/m}^2$$

3

$$ii) \epsilon_v = ?$$

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

$$K = \frac{-P}{\epsilon_v}$$

$$\epsilon_v = \frac{-P}{K}$$

3

$$\epsilon_v = \frac{-55 \times 10^6}{136 \times 10^9} = -404.41 \times 10^{-6} \text{ No Units.}$$

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

$$-404.41 \times 10^{-6} \times (0.3)^3 = -10.912 \times 10^{-6} \text{ m}^3$$

2

iii) An orthotropic material is a material that has different material properties in different directions. An example would be compounds such as paper or carbon fibre.

2

Slope = $\frac{dy}{dx}$
deflection = y .

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3. ~~iii~~) $R_A = 1312.9 \text{ N}$ $EI = 1 \times 10^6 \text{ pa.}$
 $R_B = 1387.1 \text{ N}$

i) $EI = \frac{d^2x}{dy^2}$

↑ -ve
OK.

$$M = -1312.9[x] + \frac{100[x-0.5]^2}{2} - \frac{100[x-1.5]^2}{2} \checkmark$$

$$+ 2 \times 10^3[x-1.5] + \frac{600[x-1.5]^2}{2} - \frac{600[x-2.5]^2}{2} \checkmark$$

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

$$+ \frac{2 \times 10^3[x-1.5]^2}{2} + \frac{600[x-1.5]^3}{6} - \frac{600[x-2.5]^3}{6} + A \checkmark$$

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

$$+ \frac{2 \times 10^3[x-1.5]^3}{6} + \frac{600[x-1.5]^4}{24} - \frac{600[x-2.5]^4}{24}$$

$$+ A[x] + B \checkmark$$

iv) ~~iii~~ $A + x=0 \quad y=0 \quad A + x=3.1 \quad y=0$

Finding B.

$$EI 0 = \frac{-1312.9[0]^3}{6} + \frac{100[0-0.5]^4}{24} - \frac{100[0-1.5]^4}{24}$$

$$+ \frac{2 \times 10^3[0-1.5]^3}{6} + \frac{600[0-1.5]^4}{24} - \frac{600[0-2.5]^4}{24}$$

$$+ A[0] + B$$

= $B = -0 + 0 - 0 + 0 + 0 - 0$

$B = 0$ ✓

$$EI_y = EIO = -1312.9 \frac{[3.1]^3}{6} + 100 \frac{[3.1 - 0.5]^4}{24} - 100 \frac{[3.1 - 1.5]^4}{24} + 2 \times 10^3 \frac{[3.1 - 1.5]^3}{6} + 600 \frac{[3.1 - 1.5]^4}{24} - 600 \frac{[3.1 - 2.5]^4}{24} + A[3.1]$$

$$EI_y = EIO = -1312.9 \frac{[3.1]^3}{6} + 100 \frac{[3.1 - 0.5]^4}{24} - 100 \frac{[3.1 - 1.5]^4}{24} + 2 \times 10^3 \frac{[3.1 - 1.5]^3}{6} + 600 \frac{[3.1 - 1.5]^4}{24} - 600 \frac{[3.1 - 2.5]^4}{24} + A[3.1]$$

$$= EIO = -6.52 \times 10^3 + 196.41 - 27.31 + 1.37 \times 10^3 + 163.84 - 3.24 + A[3.1]$$

Calculator error
X

$$A[3.1] = -63506.3 \Rightarrow A = \frac{-63506.3}{3.1} = -20.49 \times 10^3$$

V. $\alpha = 1.55$. $EI = 1 \times 10^6$

$$1 \times 10^6 = -1312.9 \frac{[1.55]^3}{6} + 100 \frac{[1.55 - 0.5]^4}{24} - 100 \frac{[1.55 - 1.5]^4}{24} + 2 \times 10^3 \frac{[1.55 - 1.5]^3}{6} + 600 \frac{[1.55 - 1.5]^4}{24} - 600 \frac{[1.55 - 2.5]^4}{24}$$

$$1 \times 10^6 = -814.86 + 5.06 - 26.04 \times 10^{-6} + 0.042 + 156.25 \times 10^{-6} - 20.49 \times 10^3$$

error carried

$$1 \times 10^6 = -21.3 \times 10^3$$

$$y = \frac{-21.3 \times 10^3}{1 \times 10^6} = -21.3 \times 10^{-3} m$$

X

4. $D = 0.28 \text{ m}$
 $L = 0.6 \text{ m}$
 $n_c = 0.55$
 $n_c = 0.65$
 $P = 14.6 \times 10^5$
 $\sigma_{\max} = 150 \times 10^6 \text{ Pa}$
 $t = ?$
 $t = ?$

$$\sigma_c = \frac{PD}{2tn_c}$$

$$\sigma_L = \frac{PD}{4tn_c}$$

~~$$\sigma_c = \frac{PD}{2tn_c}$$~~

$$t = \frac{PD}{2\sigma_c n_c}$$

$$t = \frac{PD}{4\sigma_L n_c}$$

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

$$t = \frac{14.6 \times 10^5 \times 0.28}{4 \times 150 \times 10^6 \times 0.65}$$

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

$$t = 1.05 \times 10^{-3} \text{ m}$$

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

$$\begin{aligned}
 5. \quad D_o &= 0.048 \text{ m} \\
 D_i &= 0.038 \text{ m} \\
 r_o &= 0.024 \\
 r_i &= 0.019 \\
 P &= 145 \times 10^5 \text{ Pa}
 \end{aligned}$$

$$i) \sigma_r = a - \frac{b}{r^2} \quad \checkmark \text{ radii}$$

$$@ r_o = 0.024 \quad \sigma_r = 0 \quad \checkmark$$

$$@ r_i = 0.019 \quad \sigma_r = -145 \times 10^5 \text{ Pa} \quad \checkmark$$

3

$$ii) \sigma_r = a - \frac{b}{r^2}$$

$$\sigma_r = a - \frac{b}{r^2}$$

0

$$\sigma_r = a - \frac{b}{0.024^2}$$

$$-145 \times 10^5 = a - \frac{b}{0.019^2}$$

0

$$\sigma_r = b - (0.024)^2 a \quad \checkmark$$

$$+145 \times 10^5 (0.019)^2 = b - a(0.019)^2 \quad \checkmark$$

$$b = - (0.024)^2 a \quad \times \text{error carries}$$

$$+145 \times 10^5 (0.019)^2 = - (0.024)^2 a - (0.019)^2 a$$

$$+145 \times 10^5 (0.019)^2 = a(-0.024^2 - 0.019^2) \quad \times$$

$$a = \frac{-(0.024^2 - 0.019^2)}{+145 \times 10^5 + 0.19^2}$$

$$= \frac{-4/10.74 \times 10^{-4}}{145 \times 10^5 + 0.19^2}$$

$$a = -179 \times 10^{-9}$$

x

$$\sigma_c = a + \frac{b}{r^2}$$

inner

$$\sigma_c = -1.79 \times 10^{-9} + \frac{-(0.024)^2 \times -1.79 \times 10^{-9}}{0.019}$$

$$= -1.74 \times 10^{-9} \text{ Nm}^2$$

$$\text{Outer} = -1.79 \times 10^{-9} + \frac{-(0.024)^2 \times -1.79 \times 10^{-9}}{0.024}$$

$$= -1.75 \times 10^{-9} \text{ Nm}^2$$

inner

$$\sigma_c = a + \frac{b}{r^2}$$

$$\sigma_c = -179 \times 10^{-9} + \frac{(-0.024^2) \times -179 \times 10^{-9}}{0.019^2}$$

$$= 0.051 \times 10^{-9} \text{ Nm}^2$$

Outer

$$\sigma_c = a + \frac{b}{r^2}$$

$$-179 \times 10^{-9} + \frac{(-0.024^2 \times -179 \times 10^{-9})}{0.024^2} = -0.032 \text{ Nm}^2 \times 10^{-9}$$

Question No.

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