Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	SOLID MECHANICS 2
COURSE CODE	:	BDA20903
PROGRAMME	:	BDD
EXAMINATION DATE	:	FEBRUARI 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **FOUR(4)** OUT OF **FIVE(5)** QUESTIONS. 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK**. 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 The bracket in **Figure Q1** is made of steel with $E_{steel} = 210GPa$, and $\nu_{steel} = 0.3$. Due to the given loadings, the gauges at point A which is located on the surface of the bracket give the following readings

$$\varepsilon_a = 500x10^{-6}, \quad \varepsilon_b = 400x10^{-6}, \quad \varepsilon_c = -65x10^{-6}$$

Referring to the given measurements of strains, determine:

(a) The principal strains at point A, and

(15 marks)

(b) The corresponding principal stresses at point A

(10 marks)

Q2 (a) Explain the advantages of using Macaulay's function to define an elastic curve

(2 marks)

(b) **Figure Q2** shows a simply supported beam ABCD exerted with distributed loading. Suppose the beam in equilibrium conditions

(i) Sketch the Free Body Diagram of the beam,

(4 marks)

(ii) Find support reactions force at points B and D,

(4 marks)

(iii) Determine the equation of the elastic curve, and

(12 marks)

(iv) Calculate the slope at point C.

(3 marks)

Q3 A horizontal beam BC is subjected to uniformly distributed load, w and at the same time it is supported at end B by a column AB (diameter of 50 mm) as shown in **Figure Q3**. Factor of safety with respect to buckling is 2.0 and the column is made of steel alloy with structural A992. Assume that all bars are pin-connected. Given E=200GPa.

(a) Sketch a complete Free Body Diagram (FBD) for the beam with clearly shows the concentrated load and reaction forces acted upon the beam.

(4 marks)

(b) From the FBD, determine the equation of force for member AB, P_{AB}.

(4 marks)

(c) Calculate the critical force, $P_{cr,x}$ and $P_{cr,y}$ associated with member AB.

(9 marks)

(d) By consider the factor of safety, determine the uniformly distributed load, w that can be applied onto beam BC without causing a column AB to buckle.

(8 marks)

Q4 A compound cylinder is formed by shrinking tube of 320 mm internal diameter and 40 mm thickness onto another tube of 320 mm external diameter and 40 mm thick, both tubes being made of the same material. The radial pressure at the common surface, after shrinking is 160 MPa. The compound tube is then subjected to an internal fluid pressure of 1000 MPa:

(a) Sketch the Free Body Diagram of the cylinder.

(4 marks)

(b) Determine the hoop stresses at inner radius and outer radius of inner cylinder, and

(11 marks)

(c) Calculate the hoop stresses at inner radius and outer radius of outer cylinder.

(10 marks)

Q5 (a) Explain the maximum principal stress theory of elastic failure and its corresponding equation including its failure envelope.

(5 marks)

(b) The proportional limit of a certain steel is 300 MPa in simple tension. It is subjected to principal tensile stresses of 150 MPa. According to the maximum principal stress theory, the safety factor in this case would be?

(5 marks)

(c) A solid shaft shown in **Figure Q5** has a radius, r of 15 mm and is made of steel having a yield stress of 360 MPa. Determine the maximum torsion(T), so that the shaft does not fail according to following theories:

(i) Maximum-shear-stress theory

(7 marks)

(ii) Maximum-distortion-energy theory

(8 marks)

END OF QUESTIONS

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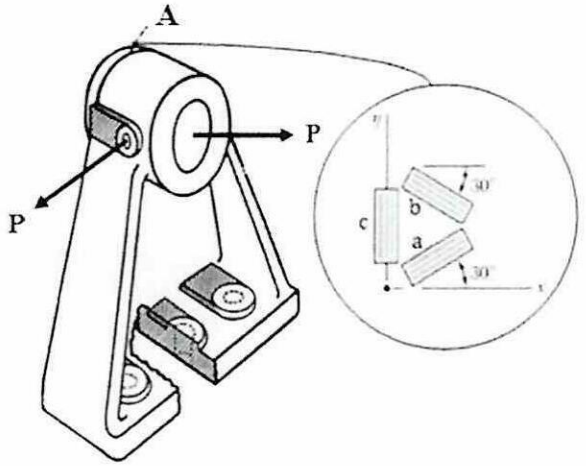

Figure Q1

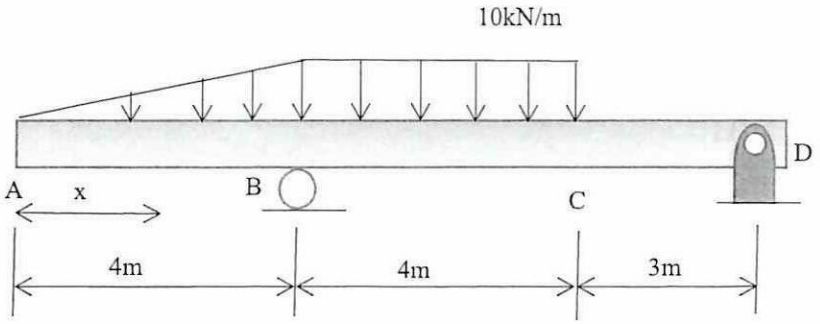

Figure Q2

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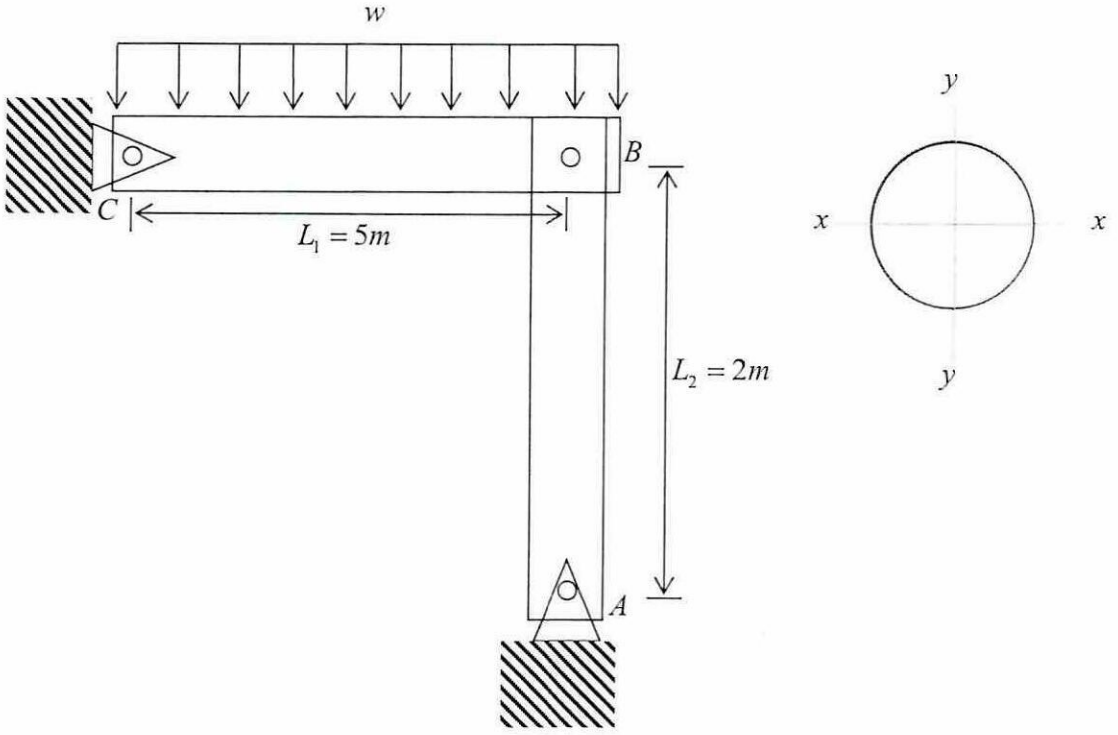

Figure Q3

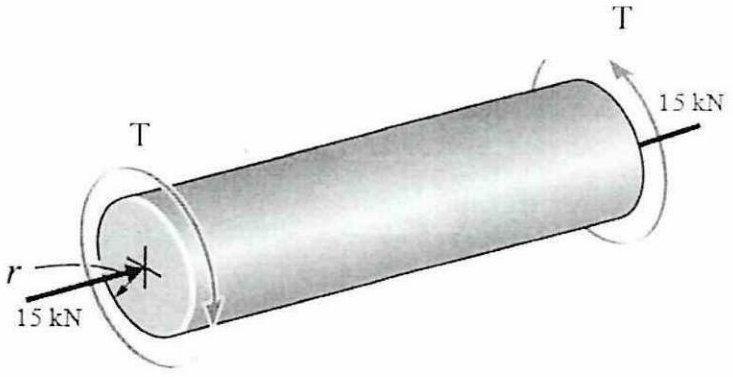

Figure Q5

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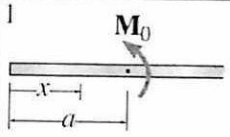
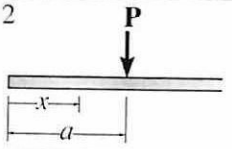
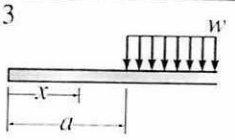
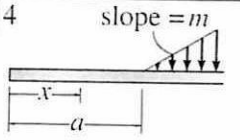
Related Equations for References:

Loading	Loading Function $w=w(x)$
1 	$w = M_0\langle x-a\rangle^{-2}$
2 	$w = P\langle x-a\rangle^{-1}$
3 	$w = w_0\langle x-a\rangle^{0}$
4 	$w = m\langle x-a\rangle^{1}$

$$EI\frac{d^4y}{dx^4} = -w(x)$$

$$EI\frac{d^3y}{dx^3} = V(x)$$

$$EI\frac{d^2y}{dx^2} = M(x)$$

$$\epsilon_a = \epsilon_x \cos^2\theta_a + \epsilon_y \sin^2\theta_a + \gamma_{xy} \sin\theta_a \cos\theta_a$$

$$\epsilon_b = \epsilon_x \cos^2\theta_b + \epsilon_y \sin^2\theta_b + \gamma_{xy} \sin\theta_b \cos\theta_b$$

$$\epsilon_c = \epsilon_x \cos^2\theta_c + \epsilon_y \sin^2\theta_c + \gamma_{xy} \sin\theta_c \cos\theta_c$$

$$\tan 2\theta p = \frac{\gamma_{xy}/2}{(\epsilon_x - \epsilon_y)/2}$$

$$\tan 2\theta s = \frac{(\epsilon_x - \epsilon_y)/2}{-\gamma_{xy}/2}$$

$$\gamma_{xy} = \frac{1}{G}\tau_{xy}$$

$$\frac{\gamma_{max\ in\ plane}}{2} = \sqrt{\left(\frac{\epsilon_x - \epsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$$

$$\epsilon_x = \frac{1}{E}[\sigma_x - v(\sigma_y + \sigma_z)]$$

$$G = \frac{E}{2(1+v)}$$