UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	SOLID MECHANICS II
COURSE CODE	:	BDA 20903
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER **FIVE (5)** QUESTIONS FROM SIX (6) QUESTIONS ONLY 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 Please answer the following questions:

(a) Referring to the material element in **Figure Q1.1**, determine the corresponding state of strain at resulting from the two states of strain shown using Mohr's circle and element diagram.

(8 marks)

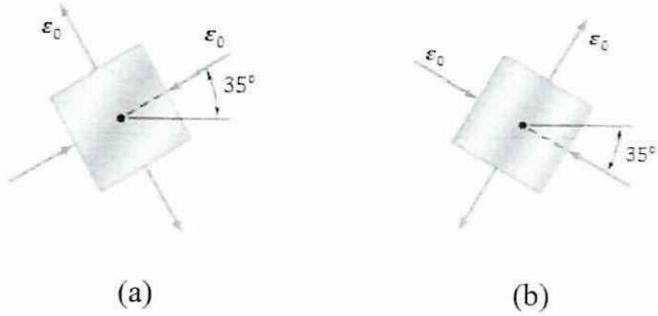


Figure Q1.1 Material Element

(b) The bracket in **Figure Q1.2** is made of steel for which E_{steel} = 200 GPa and ν_{steel} = 0.3. Due to the applied loading, the gauge readings at point A, located on the surface of the bracket, are provided as $\varepsilon_a = 600\text{x}10^{-6}$, $\varepsilon_b = 450\text{x}10^{-6}$, $\varepsilon_c = -75\text{x}10^{-6}$. Referring to the given measurements:

(i) Determine the principal strains, ε_1 and ε_2 at point A using Mohr's circle approach.

(8 marks)

(ii) Determine the corresponding principal stresses, σ_1 and σ_2 at this point.

(4 marks)

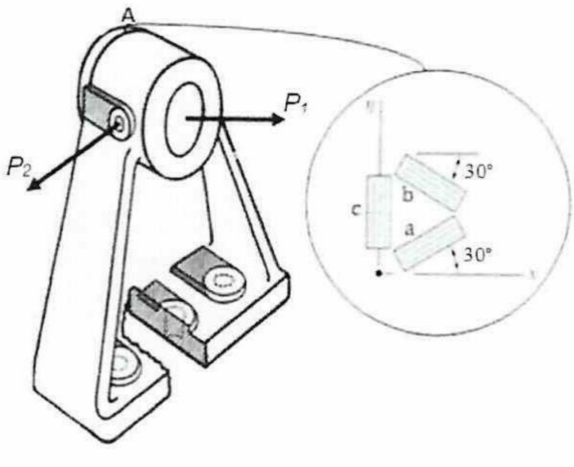


Figure Q1.2 Steel Bracket

Q2 Please answer the following questions:

(a) State three different types of end supports and their associated boundary conditions.

(6 marks)

(b) Explain a statically indeterminate beam.

(2 marks)

(c) **Figure Q2.1** shows a beam subjected to a concentrated loading. Determine support reactions at points A and B:

(12 marks)

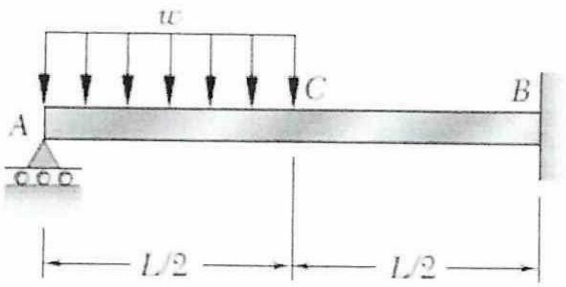


Figure Q2.1 Beam ACB

Q3 Please answer the following questions:

(a) Explain the effective length and slenderness ratio used in the analysis and design of column.

(4 marks)

(b) Steel bar AB in **Figure Q3.1** is pin connected at its ends for buckling in y-y axis. Given $w = 4\text{kN/m}$, $E_{st} = 210$ GPa and $\sigma_Y = 380$ MPa:

(i) Draw Free Body Diagram (FBD) of the frame ABC .

(4 marks)

(ii) Determine the maximum load P can be supported by the frame.

(8 marks)

(iii) Determine the factor of safety with respect to buckling about the y-y axis.

(4 marks)

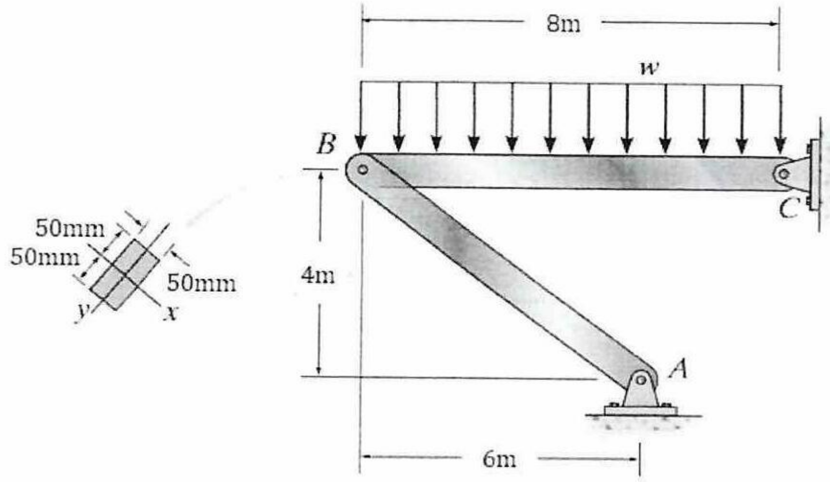


Figure Q3.1 Frame ABC

Q4 Please answer the following questions:

(a) A beam with length, L and cross-sectional area, A is loaded with a vertical load, P at the middle of its length. Using L, A, P, Young's modulus, E and moment of inertia, I derive strain energy formulation for the following types of beam:

(i) Cantilever beam.

(5 marks)

(ii) Simply supported beam.

(5 marks)

(b) Determine the reaction forces for a beam under the loading as shown in **Figure Q4.1** using the strain energy method. The beam cross-sectional area, A is 1 x 10^5 mm^2. Given $E = 200$ GPa and $I = 106 \times 10^6$ mm^4.

(10 marks)

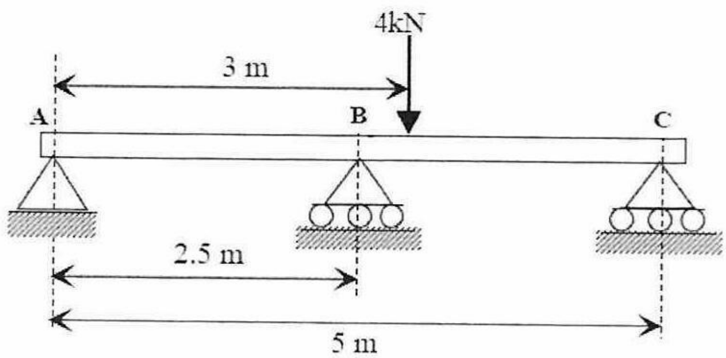


Figure Q4.1 Beam ABC

Q5 Please answer the following questions:

(a) Determine the main difference between thick and thin cylinders and provide an example for each type of cylinder.

(4 marks)

(b) Using an appropriate diagram, derive the expression for longitudinal stress, σ_L for a closed thick cylinder subjected to internal pressure, P_i where the cylinder has inner radius, r_i and outer radius, r_o.

(6 marks)

(c) **Figure Q5.1** shows a cross section of composite cylinder that is made by shrinking a tube of 330 mm internal diameter and 50 mm thick over another tube of 330 mm external diameter and 50 mm thick. The radial pressure at the common surface, after shrinking is 180 MPa. Suppose the compound cylinder is subjected to an internal fluid pressure of 1200 MPa:

(i) Determine the hoop stresses, σ_H at inner radius and outer radius of inner cylinder .

(5 marks)

(ii) Determine hoop stresses, σ_H at inner radius and outer radius of outer cylinder.

(5 marks)

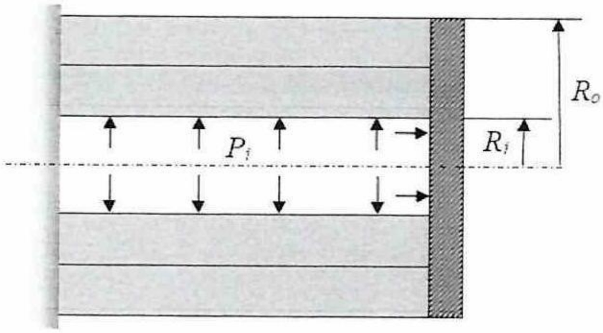


Figure Q5.1 Composite Cylinder

Q6 The shaft in **Figure Q6.1** is made of steel with a proportional limit of 360 MPa in tension or compression, and factor of safety of 2.0 with respect to failure:

(a) Explain the Maximum Shear Stress Theory and the Maximum Distortion Energy Theory of Failures.

(4 marks)

(b) Determine the principal stresses of the shaft using the above theories.

(6 marks)

(c) Determine the minimum permissible diameter, D according to these theories.

(10 marks)

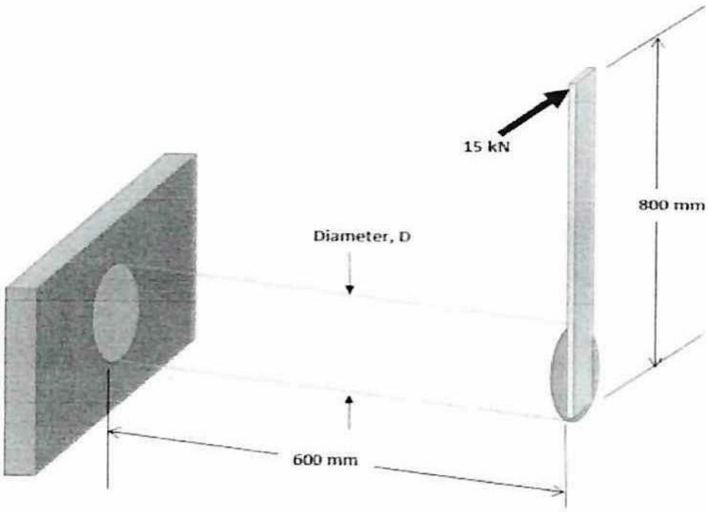
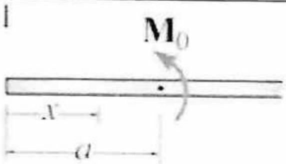
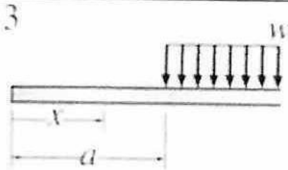
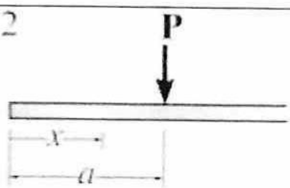
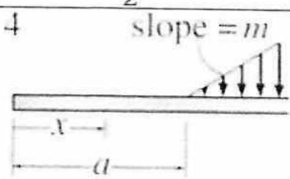


Figure Q6.1 Steel Shaft

- END OF QUESTIONS -

APPENDIX A

Table APPENDIX A.1 Formula

$\varepsilon_{x'} = \frac{\varepsilon_x + \varepsilon_y}{2} + \frac{\varepsilon_x - \varepsilon_y}{2} cos\, 2\theta + \frac{\gamma_{xy}}{2} sin\, 2\theta$	
$\varepsilon_{y'} = \frac{\varepsilon_x + \varepsilon_y}{2} - \frac{\varepsilon_x - \varepsilon_y}{2} cos\, 2\theta - \frac{\gamma_{xy}}{2} sin\, 2\theta$	
$\varepsilon_{max.min} = \frac{\varepsilon_x + \varepsilon_y}{2} + \sqrt{\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$	
$\varepsilon_a = \varepsilon_x \cos^2\theta_a + \varepsilon_y \sin^2\theta_a + \gamma_{xy} \sin\theta_a \cos\theta_a$	
$\varepsilon_x = \frac{1}{E}[\sigma_x - v(\sigma_z + \sigma_y)]$	$G = \frac{E}{2(1+v)}$
$U = \frac{P^2 L}{2AE}$	$U = \int_0^L \frac{M^2}{2EI} dx$
$U = \frac{T^2 L}{2GJ}$	$x = \frac{\delta U}{\delta P} = \int_0^L \frac{M}{EI}\frac{\delta M}{\delta P} dx$
$\sigma_Y{}^2 = \sigma_1{}^2 + \sigma_2{}^2 + \sigma_3{}^2 - 2v(\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_3\sigma_1)$	$Pcr = \frac{\pi^2 EI}{(KL)^2}$
$\frac{\sigma_Y}{2} = \frac{(\sigma_1 - \sigma_2)}{2}$	$\sigma_Y{}^2 = \sigma_1{}^2 - \sigma_1\sigma_2 + \sigma_2{}^2$
$U = \frac{1}{2E}[\sigma_1{}^2 + \sigma_2{}^2 + \sigma_3{}^2 - 2v(\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_3\sigma_1)]$	Pin-pin k=1; Fix-fix, k= 0.5; Pin-fix, k= 0.7; Fix-free, k=2
1  $M = -M_0\langle x - a\rangle^0$	3  $M = \frac{-w_0}{2}\langle x - a\rangle^2$
2  $M = -P\langle x - a\rangle^1$	4  $M = \frac{-m}{6}\langle x - a\rangle^3$