Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	MECHANICS OF MATERIALS
COURSE CODE	:	BFC 20903
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER ALL QUESTION IN **PART A** AND THREE (3) QUESTION IN **PART B.** 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 CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

PART A - ANSWER ALL QUESTION

Q1 **Figure Q1.1** shows a plain rectangular beam subjected to point load of 10 kN. The beam is 6 meter long with size of b =150 mm and h = 250 mm.

(a) Calculate support reaction at A and B.

(5 marks)

(b) Determine maximum shear, V_{max} and maximum moment, M_{max} using shear force and bending moment diagram.

(10 marks)

(c) Calculate maximum bending stress, σ at tension and compression in N/mm^2. Draw the bending stress diagram.

(10 marks)

(d) Determine bending stress at 75 mm above the neutral axis.

(5 marks)

(e) At support B, compute the shear stress, τ at point Q and maximum shear stress, τ_{max}. Draw the shear stress diagram.

(10 marks)

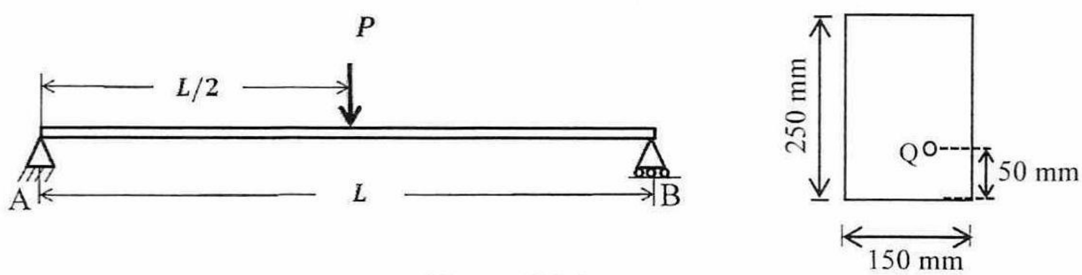


Figure Q1.1

PART B - ANSWER THREE (3) QUESTIONS ONLY

Q2 Answer the following questions.

(a) External axial forces applied to a rigid body tend to deform the body. The external forces acting on a rigid body are termed loads, the deformation is known as strain, and the internal resistance to the external force is called stress. Sketch a stress-strain diagram for steel material including all its important characteristics. Then briefly discuss on the elastic limit and the yield point of the material.

(5 marks)

(b) A control rod made from a yellow brass must not stretch more than t mm when the tension force of P kN is applied. If the modulus of elasticity is E GPa and the maximum allowable normal stress is σ_{all} MPa, determine,

(i) The smallest allowable diameter for a yellow brass control rod.

(3 marks)

(ii) The maximum length of the rod under these specified conditions.

(2 marks)

(c) **Figure Q2.1** shows the principal stress after the element has been rotated through 25° clockwise. Using the equation method, determine the stress component exerted on the axis before the rotation.

(10 marks)

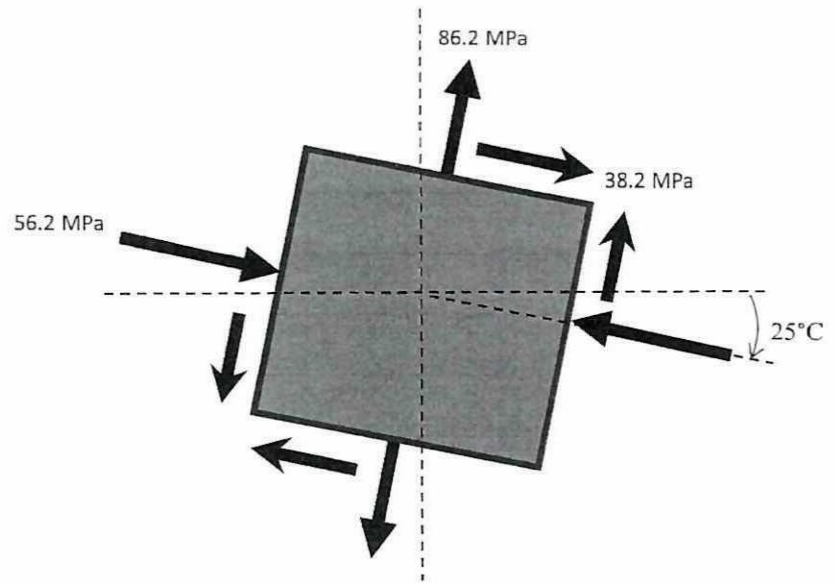


Figure Q2.1

Q3 **Figure Q3.1** shows a steel beam is subjected to uniformly distributed load. A rigid bar DEF is connected at point D.

(a) Determine support reaction at A and B.

(6 marks)

(b) Calculate deflection at point C using MacCaulay method. Take modulus of elasticity, E as 5×10^6 N/mm^2 and moment of inertia, I as 9×10^6 mm^4.

(14 marks)

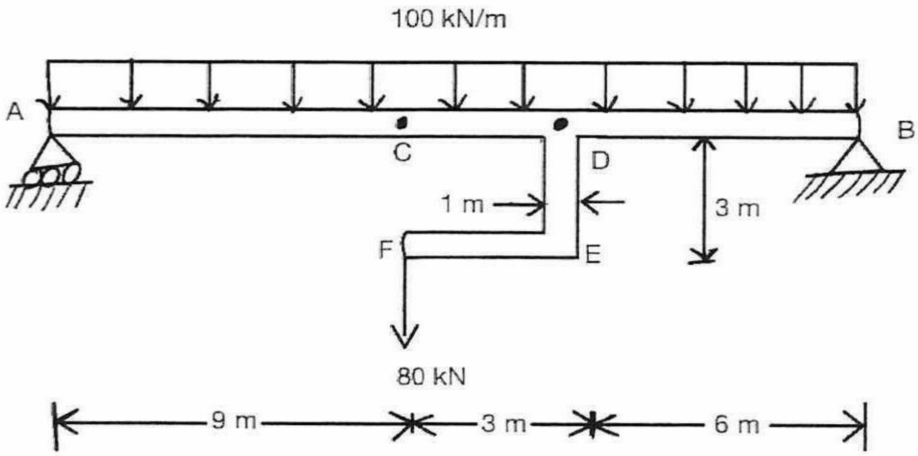


Figure Q3.1

Q4 Answer the following questions.

(a) The value of the stress corresponding to the critical load is called the critical stress and is denoted by σ_{cr}. Explain in detail the condition of column based on equation below subjected to Euler's formula.

$$\sigma_{cr} = \frac{\pi^2 E}{(L/r^2)}$$

(3 marks)

(b) A column with a 50 mm^2 section and 0.7 m effective length is made of the aluminium alloy 2014-T6. Determine the maximum load P for the column with an eccentricity of 20 mm.

(7 marks)

(c) Using the aluminium alloy 2014-T6 as shown in **Figure Q4.1**, determine the smallest diameter rod which can be used to support the centric load P = 60 kN by assuming L/r > 55 or L/r < 55 if

(i) L = 750 mm

(5 marks)

(ii) L = 300 mm

(5 marks)

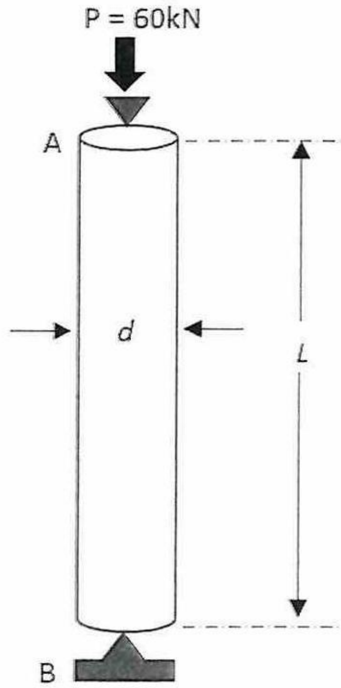


Figure Q4.1

Q5 Answer the following questions.

(a) When deriving a simple theory to describe the behaviors of a uniform circular shaft subjected to torques, it is necessary to make a few basic assumptions. State **TWO (2)** of these assumptions.

(4 marks)

(b) **Figure Q5.1** shows an aluminium hollow pole used in a roof structure with an outside and inside diameter of d_2=104 mm and d_1=82 mm, respectively. The aluminium hollow pole has length of 2.75 m and shear modulus, G = 28 GPa.

(i) If the aluminium hollow pole is twisted in pure torsion by torques acting at the ends, determine the angle of twist (in degrees) when the maximum shear stress is 48 MPa.

(8 marks)

(ii) Assuming aluminium solid pole is used, calculate the required diameter d. The pole need to resist the same torque with the same maximum stress = 48 MPa.

(6 marks)

(iii) Determine the ratio of the weight of the the aluminium hollow pole to the weight of the aluminium solid pole.

(2 marks)

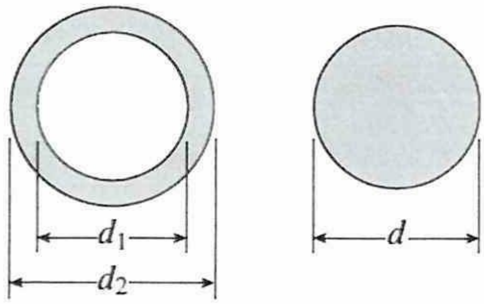


Figure Q5.1

- END OF QUESTIONS-

APPENDIX A

LIST OF EQUATIONS

A. Stress and Strain

$$\sigma = \frac{P}{A} \qquad \tau = \frac{P}{A} \qquad \varepsilon = \frac{\delta}{L} \qquad \delta = \frac{PL}{AE} \qquad F.S = \frac{F_{fail}}{F_{allow}}$$

B. Stress transformation.

$$\sigma_x{}' = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$$

$$\sigma_y' = \frac{\sigma_x + \sigma_y}{2} - \frac{\sigma_x - \sigma_y}{2}\cos 2\theta - \tau_{xy}\sin 2\theta$$

$$\tau_{xy}' = -\frac{\sigma_x - \sigma_y}{2}\sin 2\theta + \tau_{xy}\cos 2\theta$$

$$R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy^2}}$$

$$\sigma_{max,min} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy^2}}$$

$$\tan 2\theta_p = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$

C. Bending stress and shear stress

$$\frac{M}{I} = \frac{\sigma}{y} \qquad \tau = \frac{VA\bar{y}}{It} \qquad \tau_{max} = \frac{1.5V}{A}$$

D. Deformation of flexural member

(1) $EI\frac{d^4y}{dx^4} = q(x)$ Force-deflection equation

(2) $EI\frac{d^3y}{dx^3} = V(x) = \int q(x)dx + C_1$ Shear-deflection equation

(3) $EI\frac{d^2y}{dx^2} = M(x) = \iint q(x)dx^2 + C_1x + C_2$ Bending moment-deflection equation

(4) $EI\frac{dy}{dx} = EI\theta(x) = \int M(x)dx + C_3 = \iiint q(x)dx^3 + C_1x^2 + C_2x + C_3$ Slope-deflection equation

(5) $EIy(x) = \int M(x)dx^2 + C_3x + C_4 = \iiiint q(x)dx^4 + C_1x^3 + C_2x^2 + C_3x + C_4$ Deflection equation

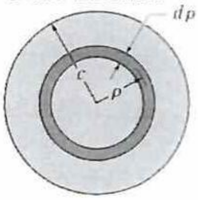
E. Buckling of compression member

$$r = \sqrt{\frac{I}{A}} \qquad Slenderness\ ratio = \frac{L}{r} \qquad \sigma_{max} = \frac{P}{A} + \frac{M_{max}y}{I} \qquad P_{cr} = \frac{\pi^2 EI}{L^2}$$

F. Torsion

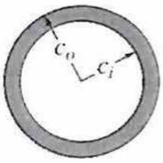
$$\tau = \frac{Tc}{J} \qquad \emptyset = \frac{TL}{JG}$$

Solid Section



$$J = \frac{\pi}{2}c^4$$

Hollow Section



$$J = \frac{\pi}{2}c_o^4 - c_i^4$$