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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	: SOLID MECHANICS
COURSE CODE	: BDU 20802
PROGRAMME CODE	: BDC
EXAMINATION DATE	: JULY/AUGUST 2023
DURATION	: 2 HOURS
INSTRUCTION	: ANSWER **ONLY FOUR (4)** QUESTIONS.

1. ANSWER **ALL** QUESTIONS FROM **SECTION A.**
2. ANSWER **TWO (2)** QUESTIONS FROM **SECTION B.**
3. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK**.
4. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

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

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SECTION A (COMPULSORY)
Answer **ALL** questions

Q1 The cylindrical pressure vessel shown in **Figure Q1** has an inner radius of 1.25 meter, 15 mm wall thickness and butt welded seams forming an angle $\beta = 45°$ with a transverse plane. The cylindrical pressure vessel is subjected to an internal pressure at gauge pressure of 8 MPa.

(i) Analyse the normal stress and the shear stress components along this welded seam by using Mohr's circle method.

(19 marks)

(ii) Determine the normal stress perpendicular to the weld by using stress transformation equation.

(3 marks)

(iii) Determine the shearing stress parallel to the weld by using stress transformation equation.

(3 marks)

Q2 The state of plane stress at a point on a body is shown on the element in the **Figure Q2.** Analyse:

(i) the element orientation, θ_p for the principle stresses.

(7 marks)

(ii) the principal stress and show the minimum and maximum stress that occur in the element.

(10 marks)

(iii) the maximum shearing stress and the corresponding normal stress. Show the maximum shearing stress and corresponding normal stress that occur in the element.

(8 marks)

SECTION B (OPTIONAL)
Answer **TWO (2)** questions **ONLY**

Q3 (a) The A-36 steel rod shown in **Figure Q3(a)** has a diameter of 50 mm and is lightly attached to the rigid supports at A and B when T_1 = 70°C. The coefficient of thermal expansion, α_{steel} = 12(10-6) / °C, E_{steel} = 200 GPa. If the temperature becomes T_1 = 10°C and axial force of P = 200 kN is applied to its center.

(i) Draw the free body diagram of the A-36 steel rod to identify the reactions at A and B

(5 marks)

(ii) Examine the reactions force at A and B.

(15 marks)

(b) In general, beams are long, straight bars having a constant cross-sectional area. Beams are important structural members used in building construction. Their design is often based upon their ability to resist bending stress. They are used to support the floor of a building, the deck of a bridge, or the wing of an aircraft. Determine and draw the shear and moment diagrams for the beam shown in **Figure Q3(b).**

(5 marks)

Q4 (a) Composite beam are formed from two materials. List **FOUR (4)** examples of composite beams.

(4 marks)

(b) A composite beam consists of a wood (E_{wood} = 11 GPa) core and two plates of steel (E_{steel} = 200 GPa) as in **Figure Q4(b)**.

(i) Describe the solution procedures to find the maximum stress in the steel and the wood.

(6 marks)

(ii) Examine the maximum stress in the steel and wood if the beam is subjected to a bending moment M = 4.5 kN.m.
(Take A= 100 mm and B = 80 mm).

(15 marks)

Q5 (a) Compare by sketch before and after the deformation of the rectangular element subjected to a torque.

(4 marks)

(b) The preliminary design of a large shaft connecting motor to a generator calls for the use of a hollow shaft with inner and outer diameter of 100 mm and 150 mm, respectively. Knowing that the allowable shearing stress is 82 MPa, Determine the maximum torque that can be transmitted by the;

(i) hollow shaft as designed .

(7 marks)

(ii) solid shaft of equal weight.

(7 marks)

(iii) hollow shaft of 200 mm diameter.

(7 marks)

- END OF QUESTIONS -

FINAL EXAMINATION

SEMESTER / SESSION : SEM II / 2022/2023 PROGRAMME CODE: BDC
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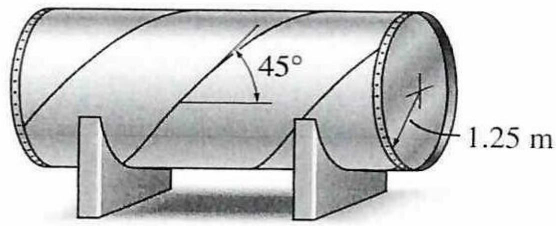

Figure Q1

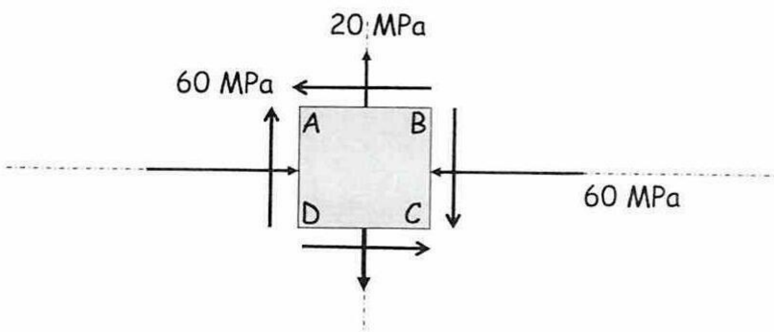

Figure Q2

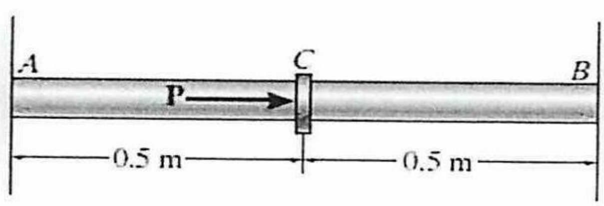

Figure Q3(a)

FINAL EXAMINATION

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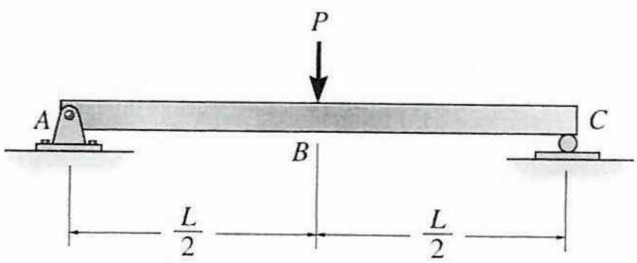

Figure Q3(b)

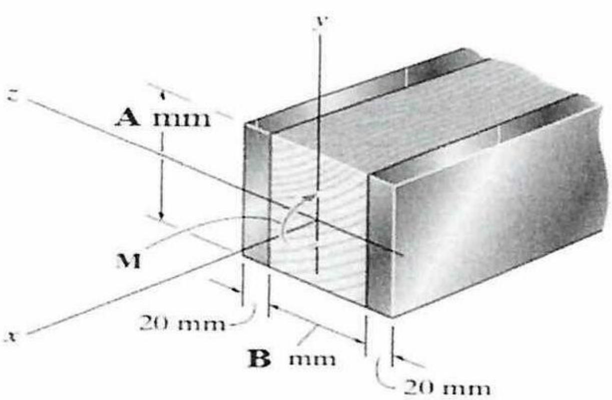

Figure 4(b)

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Fundamental Equations of Solid Mechanics

Axial Load

Normal Stress $\sigma = P/A$

Displacement $\delta = \int_0^L \frac{P(x)dx}{A(x)E}$

$\delta = \sum \frac{PL}{AE}$

$\delta_T = \alpha \Delta T L$

Torsion

Shear stress in circular shaft

$\tau = \frac{T\rho}{J}$

where

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

$J = \frac{\pi}{2}\left(c_o^4 - c_i^4\right)$ tubular cross section

Power $P = T\omega = 2\pi f T$

Angle of twist $\phi = \int_0^L \frac{T(x)dx}{J(x)G}$

$\phi = \sum \frac{TL}{JG}$

Average shear stress in a thin-walled tube

$\tau_{avg} = \frac{T}{2tA_m}$

Shear Flow $q = \tau_{avg} t = \frac{T}{2A_m}$

Bending

Normal stress $\sigma = \frac{My}{I}$

Unsymmetric stress

$\sigma = -\frac{M_z y}{I_z} + \frac{M_y z}{I_y}$, $\tan\alpha = \frac{I_z}{I_y}\tan\theta$

Material Property Relations

Poisson's ratio

$\upsilon = -\frac{\varepsilon_{lat}}{\varepsilon_{long}}$, $G = \frac{E}{2(1+\upsilon)}$

Shear

Average direct shear stress $\tau_{avg} = V/A$

Transverse shear stress $\tau = \frac{VQ}{It}$

Shear flow $q = \tau t = \frac{VQ}{I}$

Stress in Thin-Walled Pressure Vessel

Cylinder

$\sigma_1 = \frac{pr}{t}$ $\sigma_2 = \frac{pr}{2t}$

Sphere

$\sigma_1 = \sigma_2 = \frac{pr}{2t}$

Stress Transformation Equations

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

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

Principal Stress

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

$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$

Maximum in-plane shear stress

$\tan 2\theta_s = -\frac{(\sigma_x - \sigma_y)/2}{\tau_{xy}}$

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

$\sigma_{avg} = (\sigma_x + \sigma_y)/2$

Absolute maximum shear stress

$\tau_{abs\,max} = \frac{\sigma_{max} - \sigma_{min}}{2}$ $\sigma_{avg} = \frac{\sigma_{max} + \sigma_{min}}{2}$

Relations Between w, V, M

$\frac{dV}{dx} = -w(x)$, $\frac{dM}{dx} = V$