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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	SOLID MECHANICS 1
COURSE CODE	:	BDA 10903
PROGRAMMECODE	:	BDD
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTIONS		1. ANSWER ALL 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 **EIGHT (8)** PAGES

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Q1. The horizontal rigid beam *ABCD* is supported by vertical bars *BE* and *CF* and is loaded by vertical forces P_1 = 400 kN and P_2 = 360 kN acting at points *A* and *D*, respectively as shown in **Figure Q1**. Bars *BE* and *CF* are made of steel (E = 200 GPa) and have cross-sectional areas A_{BE} = 11,100 mm^2 and A_{CF} 9,280 mm^2. The distances between various points on the bars are shown in the figure. Determine:-

(a) The free body diagram

(4 marks)

(b) The reaction forces in the vertical bar

(6 marks)

(c) the vertical displacements δ_A and δ_D of points *A* and *D*, respectively.

(15 marks)

Q2. The beam ABCD as illustrated in **Figure Q2** has overhangs that extend in both directions for a distance of 4.2 m from the supports at B and C, which are 1.2 m apart.

(a) Draw the free body diagram (FBD) of the beam

(4 marks)

(b) Calculate the vertical support forces

(4 marks)

(c) Draw the Shearing Force Diagram (SFD) and the Bending Moment Diagram (BMD) of the beam

(12 marks)

(d) Determine the maximum absolute value of the bending moment

(5 marks)

Q3. A cantilever *AB* beam with a rectangular cross section has a longitudinal hole drilled throughout its length as shown in **Figure Q3**. The beam supports a load P = 600 N. The cross section is 25 mm wide and 50 mm high, and the hole has a diameter of 10 mm. Determine

(a) the bending stresses at the top of the beam

(13 marks)

(b) the bending stress at the top of the hole

(7 marks)

(c) the bending stress the bottom of the beam.

(5 marks)

Q4. The compound shaft shown in **Figure Q4** is attached to rigid supports. For the bronze segment *AB*, the maximum shearing stress is limited to 55 MPa and for the steel segment *BC*, it is limited to 83 MPa. For bronze, G = 44 GPa and for steel, G = 75 GPa. If a torque T=16270 Nm is applied as shown in the figure,

(a) draw the free-body diagram of the shaft

(3 mark)

(b) write the equations of equilibrium about axis of shaft

(3 marks)

(c) write the compatibility equation in terms of rotational displacement.

(4 marks)

(d) solve equilibrium and compatibility equations for unknown diameters

(10 marks)

(e) solve equilibrium and compatibility equations for unknown torques

(5 marks)

Q5 (a) A circular cylindrical steel tank contains a volatile fuel under pressure as shown in **Figure Q5(a)**. A strain gage at point A records the longitudinal strain in the tank and transmits this information to a control room. The ultimate shear stress in the wall of the tank is 84 MPa, and a factor of safety of 2.5 is required. Determine the value of the strain should the operators take action to reduce the pressure in the tank?

(Data for the steel are as follows: modulus of elasticity E = 205 GPa and Poisson's ratio ν = 0.30.)

(10 mark)

(b) A spherical gas container made of steel has a diameter is 500 mm, the pressure is 18 MPa, the yield stress in tension is 975 MPa, the yield stress in shear is 460 MPa, the factor of safety is 2.5, the modulus of elasticity is 200 GPa, Poisson's ratio is 0.28, and the normal strain must not exceed 1210×10^{-6}. Determine the minimum of thickness in the yield stress in tension and shear conditions?

(15 marks)

Q6 (a) For the state of stress is shown in **Figure Q6(a)**, determine the range of values of τ_{xz} for which the maximum shearing stress is equal to or less than 60 MPa.

(10 marks)

(b) The state plane stress is expected to occur in a cast iron machine base is shown in **Figure Q6(b)**. By using Mohr's circle, determine the principal stresses and maximum shear stress.

(15 marks)

- END OF QUESTION -

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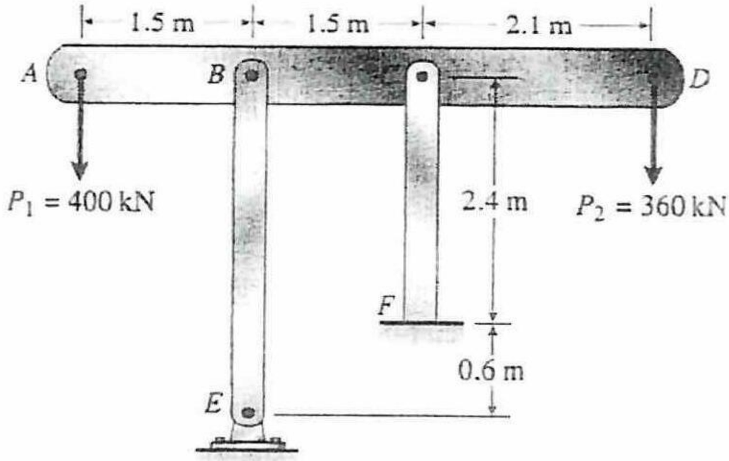

Figure Q1

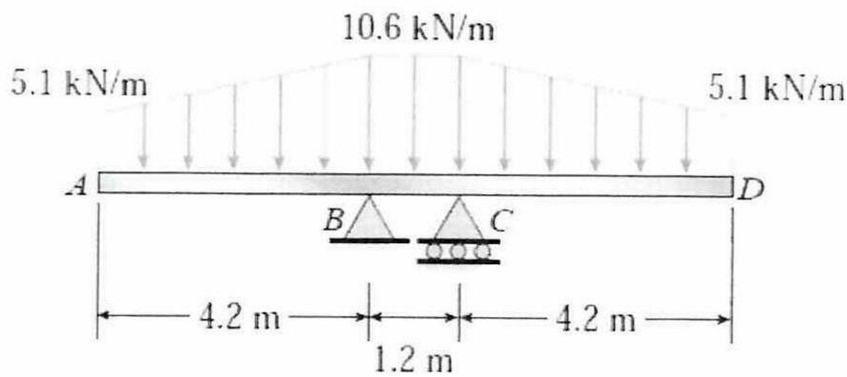

Figure Q2

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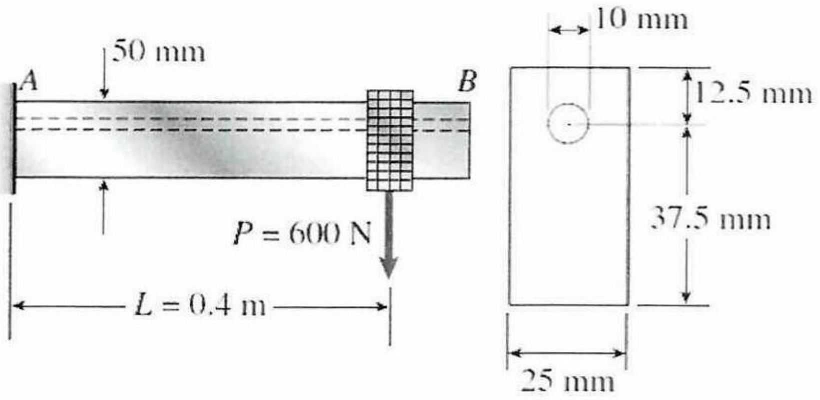

Figure Q3

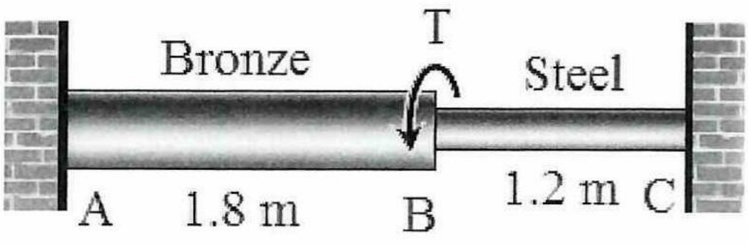

Figure Q4

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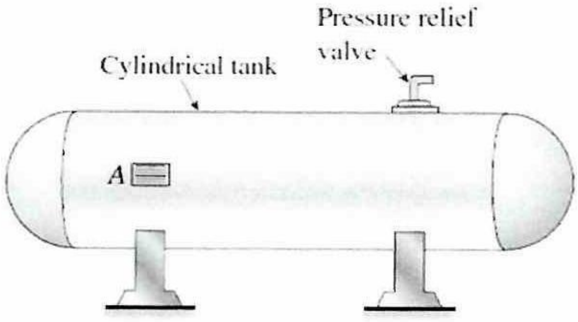

Figure Q5(a)

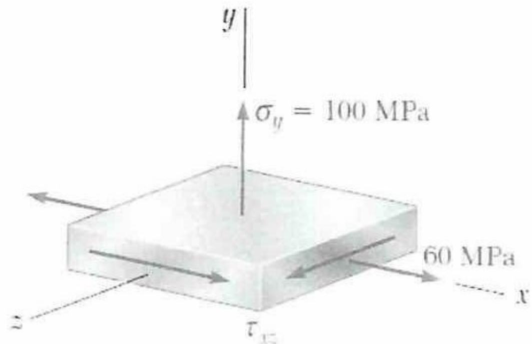

Figure Q6(a)

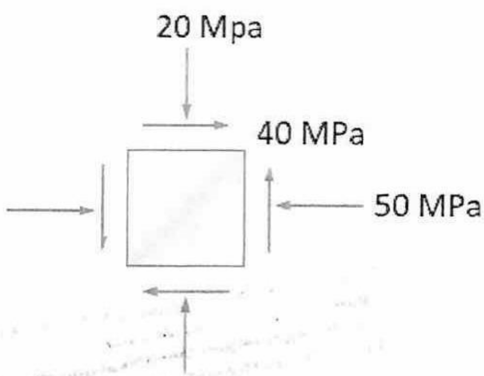

Figure Q6(b)

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EQUATIONS

$$\sigma_{ave} = \frac{P}{A} \qquad \delta = \sum_i \frac{P_i L_i}{A_i E_i}$$

$$\delta_T = \alpha(\Delta T)L \qquad n = \frac{E_2}{E_1}$$

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

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

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

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

$$\tau_{\max} = \frac{Tc}{J} \text{ and } \tau = \frac{T\rho}{J}$$

$$J = \tfrac{1}{2}\pi c^4 \qquad J = \tfrac{1}{2}\pi\left(c_2^4 - c_1^4\right)$$

$$\gamma_{\max} = \frac{\tau_{\max}}{G} = \frac{Tc}{JG} \qquad \phi = \sum_i \frac{T_i L_i}{J_i G_i}$$

$$T = \frac{P}{\omega} = \frac{P}{2\pi f} \qquad \tau_{\max} = \frac{T}{c_1 ab^2} \qquad \phi = \frac{TL}{c_2 ab^3 G}$$

$$\sigma_x = -\frac{My}{I} \qquad \frac{1}{\rho} = \frac{M}{EI}$$

$$\bar{Y} = \frac{\sum \bar{y}A}{\sum A} \qquad I_{x'} = \sum\left(\bar{I} + Ad^2\right)$$