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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER I
SESSION 2020/2021

COURSE NAME	:	SOLID MECHANICS I
COURSE CODE	:	BDA 10903
PROGRAMME	:	BDD
EXAMINATION DATE	:	JANUARY/ FEBRUARY 2021
DURATION	:	3 HOURS
INSTRUCTIONS	:	(a) ANSWER **ALL** QUESTIONS IN **PART A** (b) ANSWER **TWO (2)** QUESTIONS IN **PART B** **OPEN BOOK EXAMINATION**

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

PART A: ANSWER ALL QUESTIONS

Q1 (a) A solid circular 100 mm diameter shaft is 2 m long. The shaft is made of an aluminum alloy that has a shearing stress strain diagram that can be approximated by the two straight line shown in **Figure Q1(a).** Determine the torque required to develop a maximum shearing stress of 230 MPa in the shaft.

(10 marks)

(b) Two 8Z mm diameter steel and bronze shafts are rigidly connected and supported as shown in **Figure Q1(b)(i)** The shearing stress-strain diagram for the steel is shown in **Figure Q1(b)(ii).** The bronze has a proportional limit in shear of 84 MPa. Determine the torque required to produce a maximum shearing stress of 60 MPa in the bronze. G_{steel}=80 GPa, G_{bronze} = 45 GPa.

Take Z – The last digit of your matrix number. For example, a student with the matrix number CD150079 will have the values of diameter 89 mm

(10 marks)

Q2 A thin cylinder 75 mm internal diameter, 250 mm long with wall 2.5 mm thick is subjected to an internal pressure of 7 GPa. Determine

(a) The change in diameter and change in length

(10 marks)

(b) If, in addition to the internal pressure, the cylinder is subjected to a torque of (200+Z) Nm, calculate the magnitude of principal stresses set up in the cylinder. E =200 GPa and $\upsilon = 0.3$.

Take Z – The last two digit of your matrix number. For example, a student with the matrix number CD150079 will have a torque of 279 Nm

(10 marks)

Q3. A steel pipe ABC has diameter of 40 mm is applied a single horizontal force P of magnitude (1000+**Z)** N at end C as shown in **Figure Q3.** As knowing that this pipe is fixed at A for supported to the pipe system. Note: **Z** is the last three digit of your matrix number

(a) Draw a free body diagram for a stress element at point K.

(5 marks)

(b) Determine the normal stress and shearing stress on the element located at point K and having sides parallel to the x and y axes.

(6 marks)

(c) Determine the principal planes and the principal stresses at point K using Mohr Circle

(9 marks)

PART B: ANSWER TWO (2) QUESTIONS

Q4 (a) Rod *AB* made from steel and *BC* from bronze and subjected to loads as shown in **Figure Q4(a).** The steel has $E = 200$ GPa, a cross-sectional area of 200 mm^2 and bronze has $E = 80$ GPa, a cross-sectional area of 400 mm^2. If stresses in compression / tension is not to exceed 150 MPa in steel and not to exceed 80 MPa in bronze, determine

(i) The maximum value of *P* by considering a factor of safety = 2

(5 marks)

(ii) The change in length in both rods when carrying this maximum load P

(5 marks)

(b) A rigid bar *ABCD* as shown in **Figure Q4(b)** is pinned at end A and supported by two cables at point *B* and *C*. The cable at *B* has diameter 12 mm and the cable at *C* has diameter 2Z mm. Determine the stresses in cables if P = 20 kN and b = 1 m.

Take Z = The last digit of your matrix number. For example, a student with the matrix number CD150079 will have a diameter of 29 mm .

(10 marks)

Q5 (a) Indicate '**True**' or '**False**' for each statement.

(i) Members that are slender and support loadings that are applied perpendicular to their longitudinal axis are called beams.

(ii) A simply supported beam is pinned at one end and roller-supported at the other.

(iii) A cantilever beam is fixed at one end and free at the other.

(iv) An overhanging beam has one or both of its ends freely extended over the supports.

(v) In order to properly design a beam it is first necessary to determine the minimum shear and moment in the beam.

(vi) Shear and moment diagrams are rarely used by engineers to decide where to place reinforcement materials within the beam or how to proportion the size of the beam at various points along its length.

(vii) Shear and bending-moment functions must be determined for each region of the beam located between any two discontinuities of loading.

(viii) At a point, the slope of the shear diagrams equals the negative of the intensity of the distributed loading.

(ix) At a point, the slope of the moment diagrams is equal to the shear.

(x) For the region where the load is linear, shear is parabolic, and moment is cubic.

(10 marks)

(b) A shaft of segments *AC*, *CD*, and *DB* is fastened to rigid supports and loaded as shown in **Figure Q5(b)** with $(300+Z)$ Nm applied at point *C* and $(700+Z)$ Nm applied at point *D*. Take the modulus of rigidity for the material is $G_{Brz} = 35\,\text{GPa}$ for bronze, $G_{Al} = 28\,\text{GPa}$ for aluminum and $G_{St} = 83\,\text{GPa}$ for steel. Determine The support reactions at walls, T_A and T_B.

Take Z The last two digit of your matrix number. For example, a student with the matrix number CD150079 will have a load of 379 Nm and 779 Nm

(10 marks)

Q6 (a) The overhanging beam in **Figure Q6(a)** is subjected to the uniformly distributed loading of 5 kN/m over its 2 m length.

(i) Determine the reactions at *A* and *B*.

(4 marks)

(ii) Draw the shear and moment diagrams for the beams.

(6 marks)

(b) Two steel plates have been welded together to form a beam in the shape of a T that has been strengthened by securely bolting to it the two oak timbers as shown in **Figure Q6(b)** The modulus of elasticity is 12.5 GPa for the wood and 200 GPa for the steel. The bending moment of $M = 5Z$ kNm is applied to the composite beam and created a compressive stress at the top of beam. Determine the maximum stress developed in the wood.

Take Z – The last digit of your matrix number. For example, a student with the matrix number CD150079 will have a bending moment of $M = 59$ kNm.

(10 marks)

-END OF QUESTIONS-

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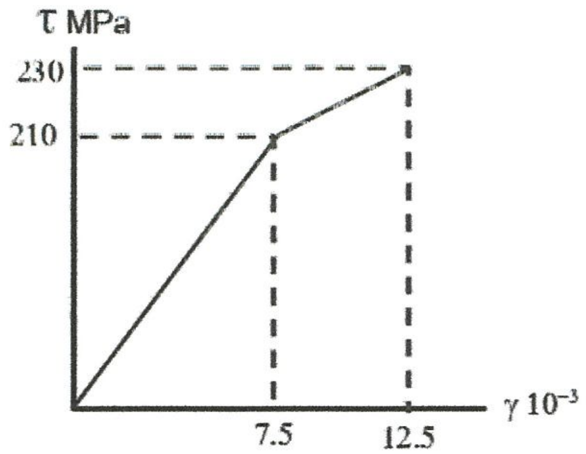

Figure Q1 (a)

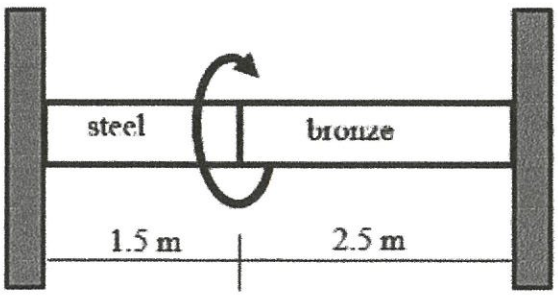

Figure Q1 (b)(i)

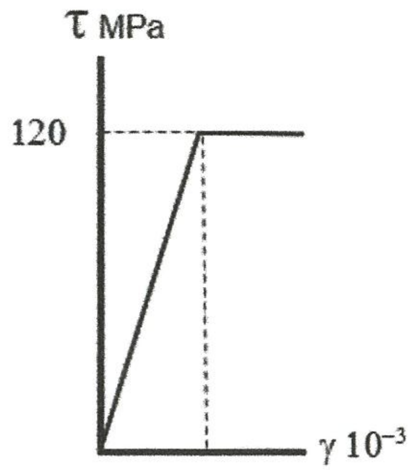

Figure Q1 (b)(ii)

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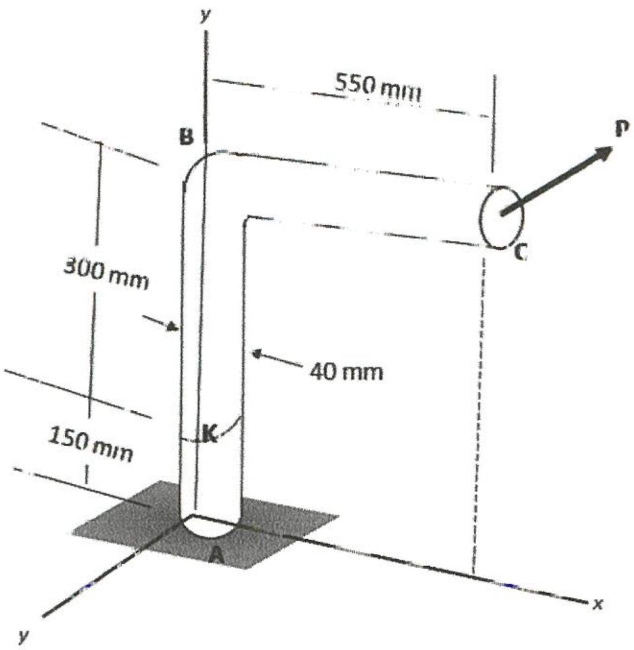

Figure Q3

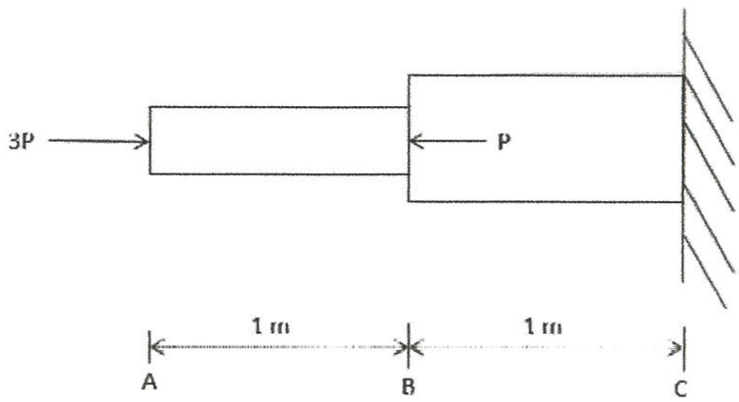

Figure Q4(a)

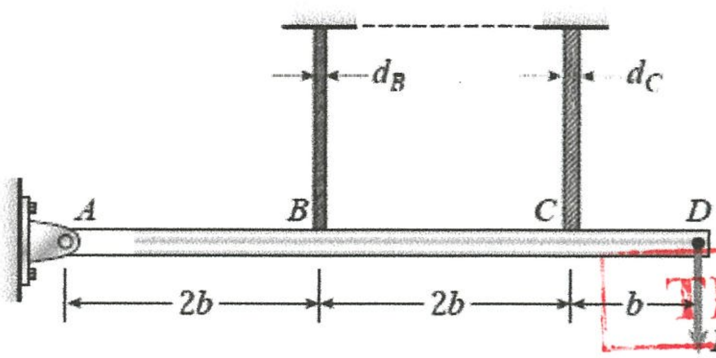

Figure Q4(b)

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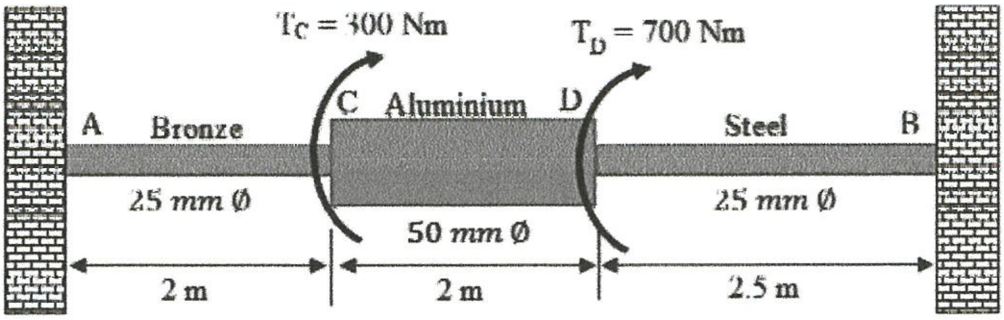

Figure Q5(b)

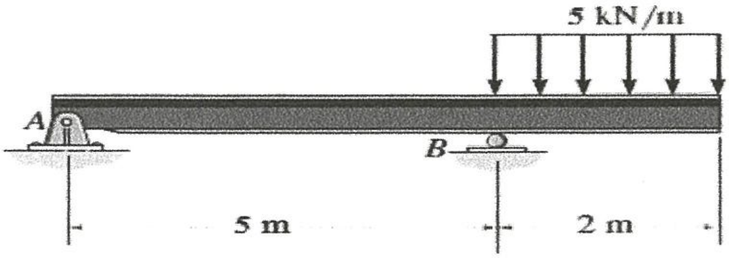

Figure Q6(a)

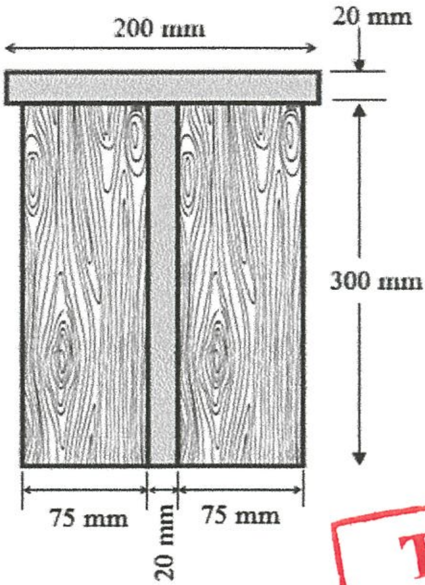

Figure Q6(b)

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Fundamental Equations of Mechanics of Materials :

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

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

Material Property Relations

Poisson's ratio

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

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

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

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

Relations Between w,V,M

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

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