UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	SOLID MECHANICS I
COURSE CODE	:	BDA 10903
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JUNE / JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	PART A : ANSWER **ONE (1)** QUESTION **ONLY** PART B : ANSWER **ALL** QUESTIONS

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

PART A (OPTIONAL) :
Answer **ONE (1)** question **ONLY**.

Q1 The three suspender bars shown in **Figure Q1** are made of A-36 steel, $E_{st} = 200\,\text{GPa}$ and have equal cross-sectional areas of $20\ \text{mm}^2$.

(a) If the load $P_1 = 30\,\text{kN}$ and P_2 on the beam causes the end of bar BE to be displaced $40\,\text{mm}$ downward, determine the magnitude of the load P_2 needed to be applied to the beam.

(11 marks)

(b) Determine the average normal stress and average normal strain developed in bar BE.

(3 marks)

(c) Determine the normal force and average normal stress in bar CF.

(3 marks)

(d) Determine the normal force and average normal stress in bar AD.

(3 marks)

Q2. A shaft of segments AC, CD, and DB is fastened to rigid supports and loaded as shown in **Figure Q2** with 300 Nm applied at point C and 700 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:

(a) The support reactions at walls, T_A and T_B.

(11 marks)

(b) The maximum shear stress in region AC, τ_{AC}

(3 marks)

(b) The maximum shear stress in region CD, τ_{CD}

(3 marks)

(b) The maximum shear stress in region DB, τ_{DB}

(3 marks)

PART B (COMPULSORY) :
Answer **ALL** questions.

Q3 (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) The overhanging beam in **Figure Q3(b)** 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)

Q4 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 Q4**. The modulus of elasticity is $12.5\,GPa$ for the wood and $200\,GPa$ for the steel. The bending moment of $M = 50\,kNm$ is applied to the composite beam and created a compressive stress at the top of beam.

(a) Determine the maximum stress developed in the wood (13 marks)

(b) Determine the stress developed in the steel along the top edge (5 marks)

(c) Sketch the stress distribution acting over the entire cross-sectional area. (2 marks)

Q5 A cylindrical pressure vessel shown in **Figure Q5** has an inner radius of $0.6\,\text{m}$ and wall thickness of $18\,\text{mm}$. It is made from steel plates. Take $E_{st} = 200\,\text{GPa}$, $\nu_{st} = 0.3$.

(a) If the vessel is subjected to the internal pressure of $2.8\,\text{MPa}$, determine the circumferential and longitudinal stress. (4 marks)

(b) Determine the normal and shear stress components along the seam if the plates are welded along a $\alpha = 55°$ with the horizontal and the vessel is subjected to an internal pressure the same as in **Q5(a)** (6 marks)

(c) Determine the maximum internal pressure and the shear stress along the seam if the plates are welded along a $\alpha = 60°$ with the horizontal and the allowable stress normal to the weld is $75\,MPa$. (10 marks)

Q6 The state of plane stress at a point is represented by the element shown in **Figure Q6(a)**.

(a) Determine the principal stresses, the maximum in-plane shear stress and average normal stress at the point. Specify the orientation of the element and sketch the state of plane-stress on the element in each case. (11 marks)

(b) Determine the equivalent state of stress if an element in **Figure Q6(a)** is oriented 15° clockwise from the element shown. Sketch the state of plane stress on an element in each case. (9 marks)

-END OF QUESTION-

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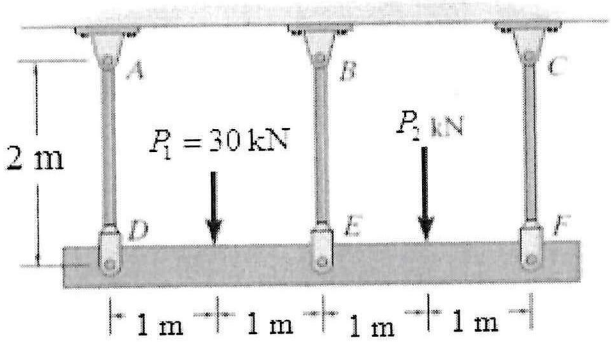

Figure Q1

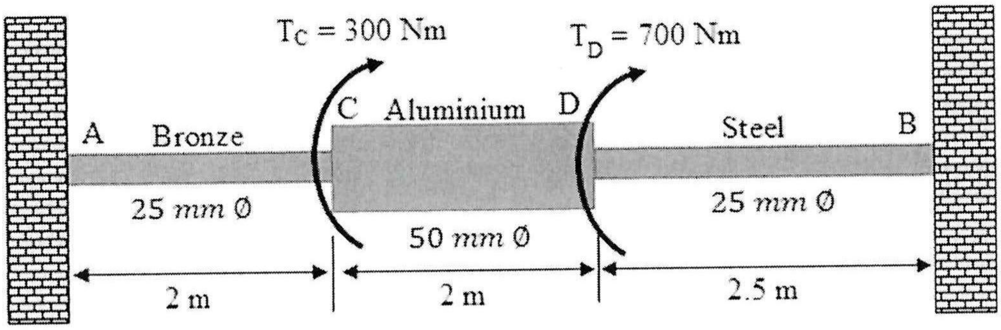

Figure Q2

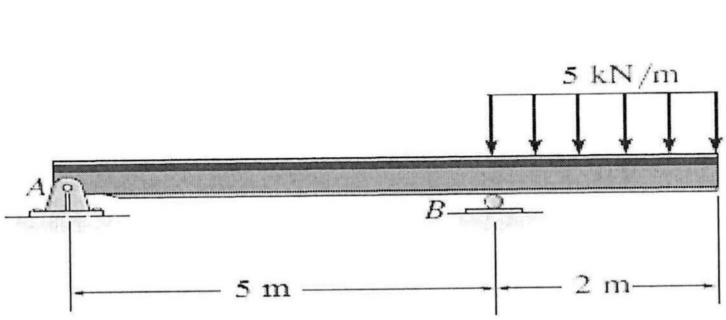

Figure Q3(b)

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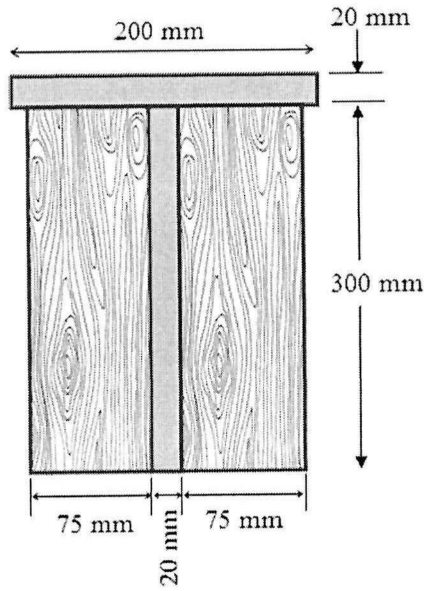

Figure Q4

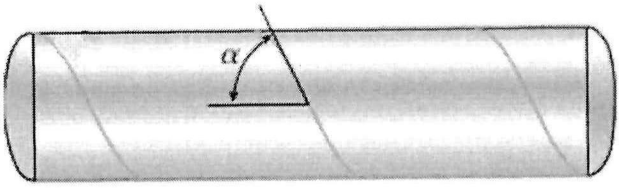

Figure Q5

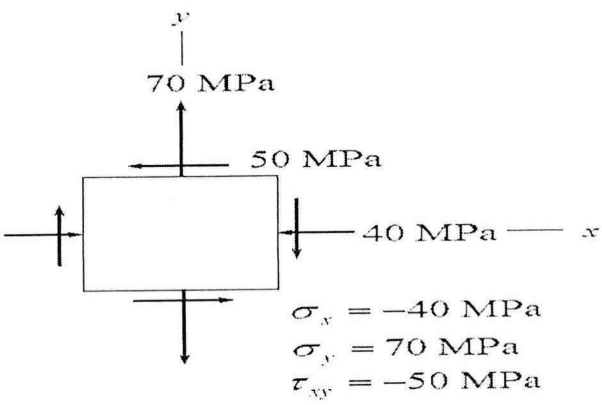

Figure Q6(a)

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Fundamental Equations of Mechanics of Materials :

Axial Load

Normal Stress $\sigma = P / A$

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

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

$\delta_T = \alpha \Delta TL$

Torsion

Shear stress in circular shaft

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

where

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

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

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

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

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