UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022

COURSE NAME	: SOLID MECHANICS
COURSE CODE	: BDU 20802
PROGRAMME CODE	: BDC
EXAMINATION DATE	: JULY 2022
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

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

Q1 (a) A thin-walled titanium alloy spherical shell has a 1 m inside diameter and is 7 mm thick. It is completely filled with an unpressurized, incompressible liquid. Through a small hole, an additional 1000 cm^3 of the same liquid is pumped into the shell, thus increasing the shell radius. For this titanium allow E = 114 GPa and the tensile yield point of the material to be 830 MPa. Determine:

(i) the pressure after the additional liquid has been introduced and the hole closed.

(7 marks)

(ii) the normal stress in the titanium shell due to this pressure.

(3 marks)

(b) The pressure tank shown in **Figure Q1 (b)** has a diameter 1.5 meter, 10 mm wall thickness and butt welded seams forming an angle $\beta = 20°$ with a transverse plane. For a gage pressure of 580 KPa. Analyse the pressure tank to obtain:

(i) the normal stress perpendicular to the weld.

(13 marks)

(ii) the shearing stress parallel to the weld.

(2 marks)

Q2 (a) The state of plane stress at a point on a body is shown on the element in the **Figure Q2(a).** 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) 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) Draw the free body diagram and determine the reactions at A and B

(7 marks)

(ii) Construct the shear and moment diagrams for the beams and examine for the maximum shear force and bending moment location.

(8 marks)

Q4 (a) Explain and show the equations of normal stress and normal strain.

(5 marks)

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

(4 marks)

(c) A composite beam is made of wood and reinforced with a steel strap located on its bottom side. It has the cross-sectional area shown in **Figure Q4(c)**. If the beam is subjected to a bending moment $M = 2$ kNm, (Take $E_{wood} = 12$ GPa and $E_{steel} = 200$ GPa).

(i) Analyse the composite beam by transform the section into a greater stiffness material to find the normal stress at point *C*.

(14 marks)

(ii) Determine the normal stress at point *B*.

(2 marks)

Q5 (a) State **THREE (3)** simple torsion theory assumption.

(3 marks)

(b) For the loading shown in **Figure Q5(b)**, shaft *BC* is hollow with inner and outer diameters of 90 mm and 120 mm, respectively. Shaft *AB* and *CD* are solid of diameter *d*.

(i) Cut sections through shaft *AB* and *BC*, perform static equilibrium analysis to find torque loadings and draw the torque diagram.

(9 marks)

(ii) Apply static torsion formulas to find minimum and maximum shearing stress on shaft *BC*.

(9 marks)

(iii) Determine the required diameter *d* of shaft *AB* and *CD* if the allowable shearing stress in these shafts is 65 MPa

(4 marks)

- END OF QUESTIONS -

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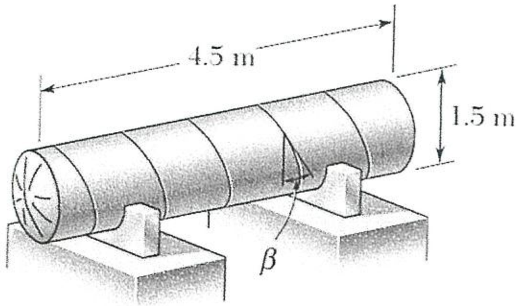

Figure Q1(b)

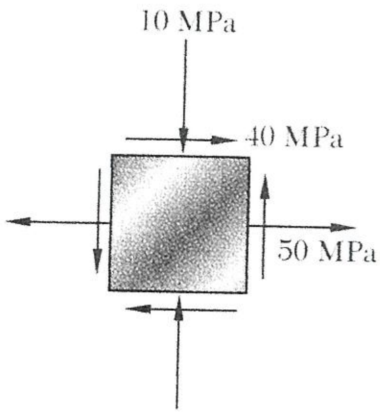

Figure Q2(a)

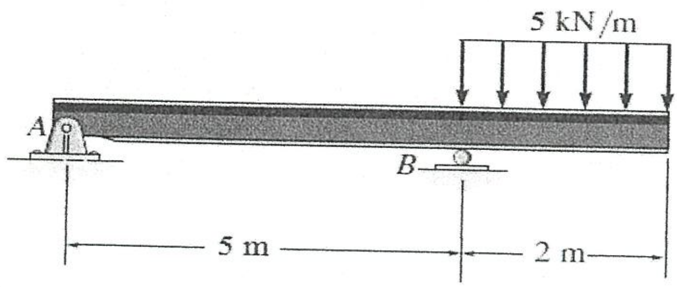

Figure Q3(b)

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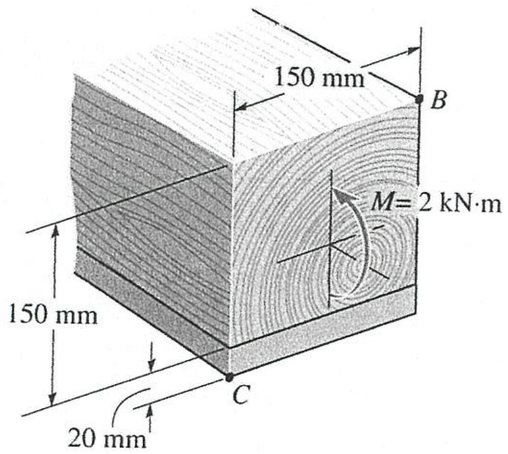

Figure 4(c)

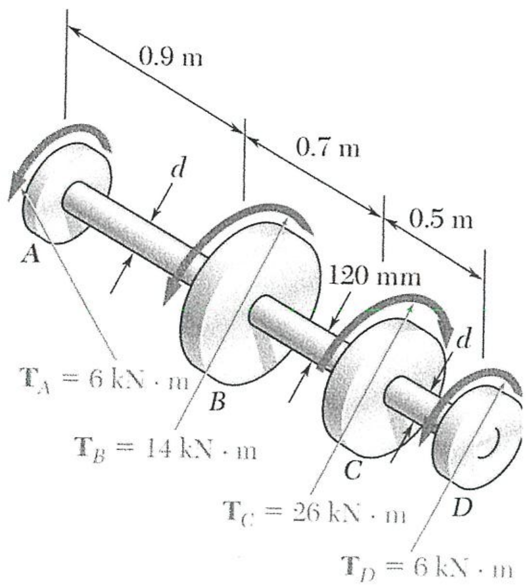

Figure Q5(b)

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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

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

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

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

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

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

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

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

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