UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015 / 2016

COURSE NAME	:	SOLID MECHANICS I
COURCE CODE	:	BDA 10402
PROGRAMME	:	BDD
EXAMINATION DATE	:	JUNE 2016
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION :	:	PART A: ANSWER **ALL** QUESTIONS PART B: ANSWER **ONE (1)** QUESTION ONLY

THIS EXAMINATION PAPER CONSISTS **SIX (6)** PAGES

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

Q1. The cylindrical pressure tank shown in **Figure Q1** has an inside diameter of 1.2 m and fabricated by butt welding 20 mm thick plate with a spiral seam. The pressure in the tank is 3000 kPa and axial load, P =130kN is applied to the end of the tank through a rigid bearing plate. Determine

(a) The normal stress perpendicular to the weld (9 marks)

(b) The shearing stress parallel to the weld (8 marks)

(c) The maximum shearing stress at a point on the outside surface of the vessel (4 marks)

(d) The maximum shearing stress at a point on the inside surface of the vessel (4 marks)

Q2. (a) **Figure Q2 (a)** shows solid rod AB which has a diameter $d_{AB} = 60\,\text{mm}$ and is made of a steel for which the allowable shearing stress is 85 Mpa. The pipe CD, which has an outer diameter of 90 mm and a wall thickness of 20 mm, is made of an aluminum for which the allowable shearing stress is 54 MPa. Both structures are welded together. Determine the largest torque T that can be applied at A and the twist angle at the end A when that torque is applied. (10 marks)

(b) The pressure tank shown in **Figure Q2(b)** has a 10 mm wall thickness and butt-welded seams forming an angle $\beta = 20°$ with a transverse plane. For a gage pressure of 600 KPa, determine:

(i) the normal stress perpendicular to the weld

(ii) the shearing stress parallel to the weld

(iii) sketch $\tau - \sigma$ diagram and indicate the answers in (b)(i) and b(ii) in the diagram. (15 marks)

Q3. The state of stress of a point on the upper surface of the airplane wing is shown on the element as in **Figure Q3**. Determine:

(a) The principle stresses (17 marks)

(b) The maximum in-plane shear stress and average normal stress at the point. Specify the orientation of the element in each case. (8 marks)

PART B (OPTIONAL) :
Answer **ONE (1)** question only.

Q4. As shown in **Figure Q4**, a rigid bar with negligible mass is pinned at O and attached to two vertical rods. Assuming that the rods were initially stress-free, what maximum load P can be applied without exceeding stresses of 200 MPa in the steel rod and 80 MPa in the bronze rod.

(25 marks)

Q5. The 60-mm diameter shaft *ABC* shown in **Figure Q5** is supported by two journal bearings, while the 80-mm diameter shaft *EH* is fixed at *E* and supported by a journal bearing at *H*. If $T_1 = 4\,\text{kNm}$ and $T_2 = 6\,\text{kNm}$, determine the angle of twist of gears *A* and *C*. The shafts are made of A-36 steel. Given $G_{steel} = 75GPa$.

(25 marks)

- END OF QUESTION –

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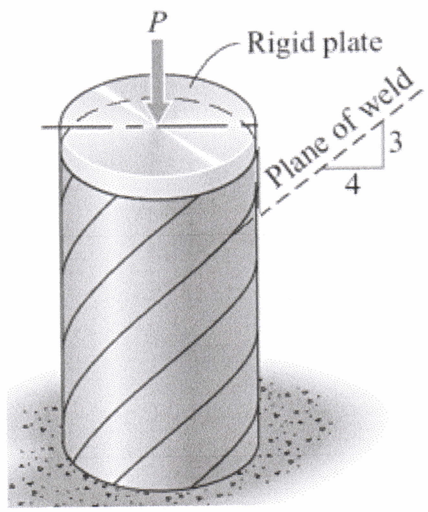

Figure Q1

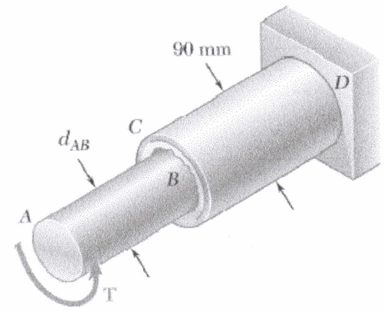

Figure Q2 (a)

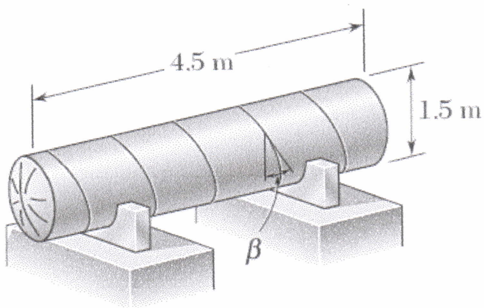

Figure Q2 (b)

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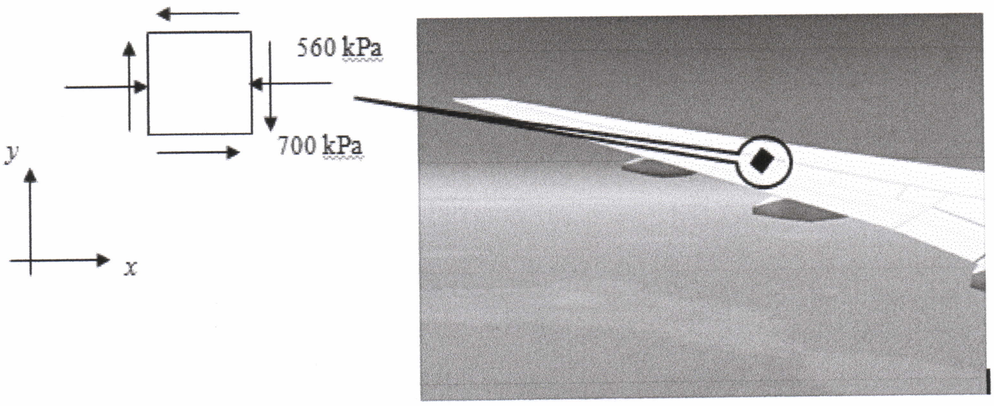

Figure Q3

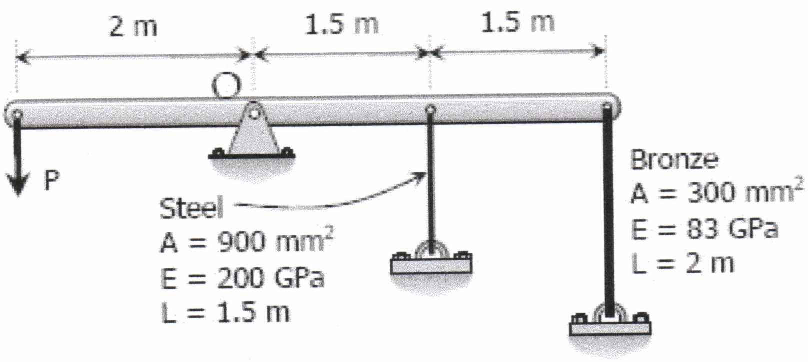

Figure Q4

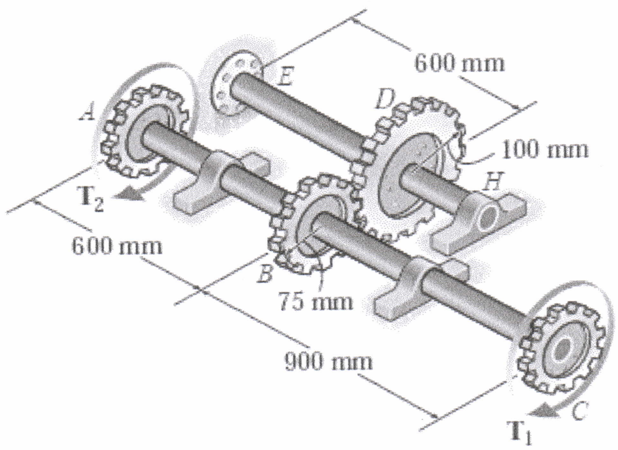

Figure Q5

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Axial Load

Normal Stress

$$\sigma = \frac{P}{A}$$

Displacement

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

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

$$\delta_T = \alpha \Delta T L$$

Torsion

Shear stress in circular shaft

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

where

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

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

Power

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

Angle of twist

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

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

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 bending

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

Shear

Average direct shear stress

$$\tau_{avg} = \frac{V}{A}$$

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

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

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

$$\sigma_{avg} = \frac{\sigma_x + \sigma_y}{2}$$

Absolute maximum shear stress

$$\tau_{\substack{abs \\ max}} = \frac{\sigma_{max} - \sigma_{min}}{2}$$

$$\sigma_{avg} = \frac{\sigma_{max} + \sigma_{min}}{2}$$

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