Universiti Tun Hussein Onn Malaysia

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION

## SEMESTER II

## SESSION 2015 / 2016

| | | |
|---|---|---|
| COURSE NAME | : | SOLID MECHANICS I |
| COURCE CODE | : | BDA 10903 |
| PROGRAMME | : | BDD |
| EXAMINATION DATE | : | JUNE 2016 |
| DURATION | : | 3 HOURS |
| INSTRUCTION : | : | PART A: ANSWER **ALL** QUESTIONS<br>PART B: ANSWER **ONE (1)** QUESTION ONLY |

THIS EXAMINATION PAPER CONSISTS **SEVEN (7)** PAGES

**CONFIDENTIAL**

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

**Q1.** The rectangular tube shown in **Figure Q1** is extruded from an aluminium alloy for which $\sigma_y = 275$ MPa, $\sigma_u = 414$ MPa, and $E = 73$ GPa. Neglecting the effect of fillets, determine

(a) The bending moment M for which the factor of safety will be 3.0
(14 marks)

(b) The corresponding radius of curvature of the tube
(6 marks)

**Q2.** The cylindrical pressure tank shown in **Figure Q2** 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 2800 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
(7 marks)

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

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

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

**Q3.** (a) **Figure Q3 (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.
(8 marks)

(b) The pressure tank shown in **Figure Q3(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 580 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.

(12 marks)

**Q4.** The state of stress of a point on the upper surface of the airplane wing is shown on the element in **Figure Q4**. Determine:

(a) The principle stresses

(14 marks)

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

(6 marks)

**PART B (OPTIONAL) :**

Answer **ONE (1)** question only.

**Q5.** As shown in **Figure Q5**, 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 150 MPa in the steel rod and 70 MPa in the bronze rod.

(20 marks)

**Q6.** The 60-mm diameter shaft *ABC* shown in **Figure Q6** 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 $T_1 = 2\text{kNm}$ and $T_2 = 4\text{kNm}$, determine the angle of twist of gears *A* and *C*. The shafts are made of A-36 steel. Given $G_{steel} = 75GPa$.

(20 marks)

**- END OF QUESTION -**

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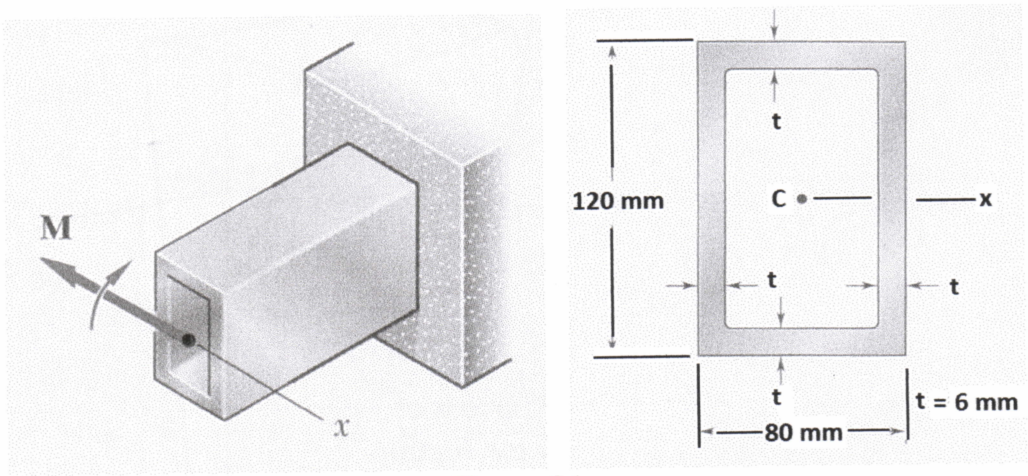


Figure Q1

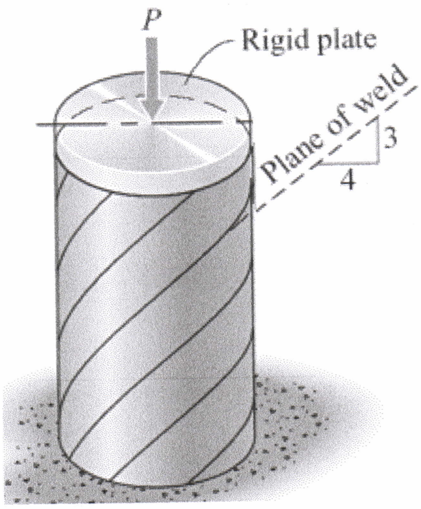


Figure Q2

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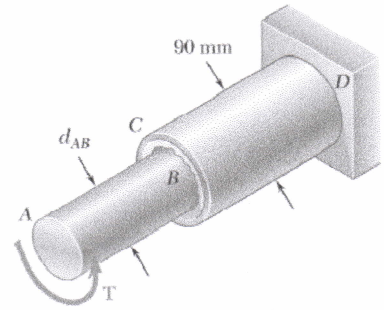


**Figure Q3 (a)**

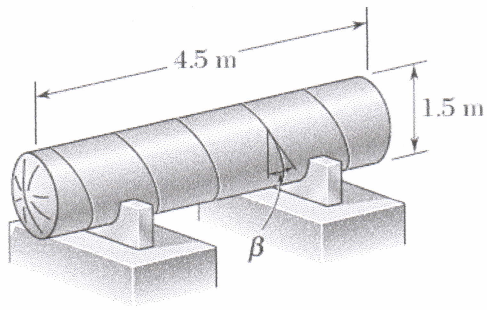


**Figure Q3 (b)**

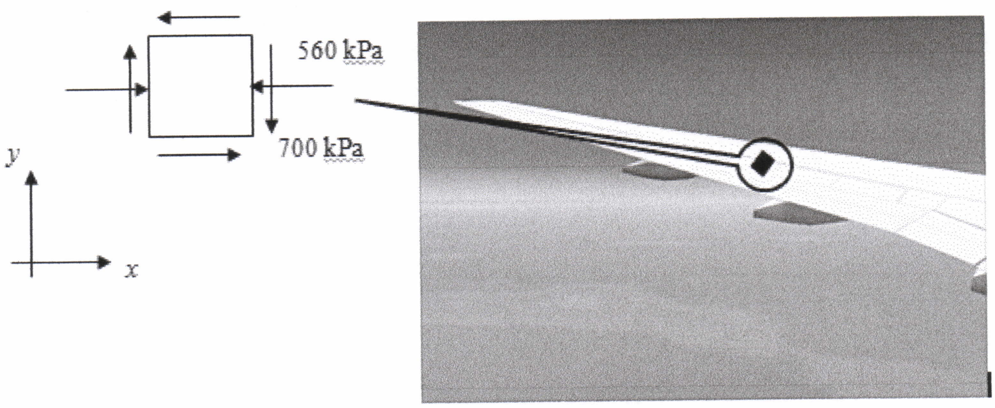


**Figure Q4**

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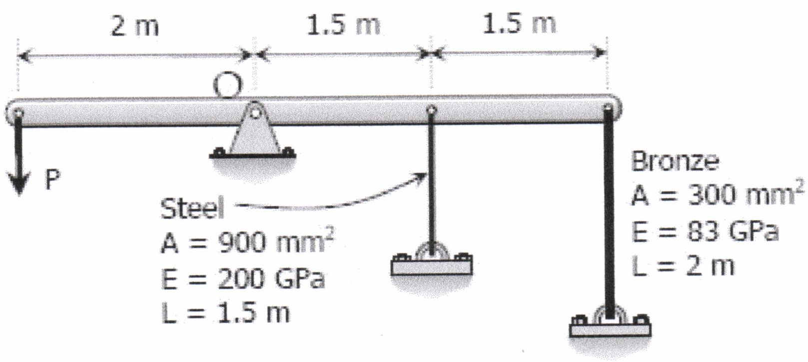


**Figure Q5**

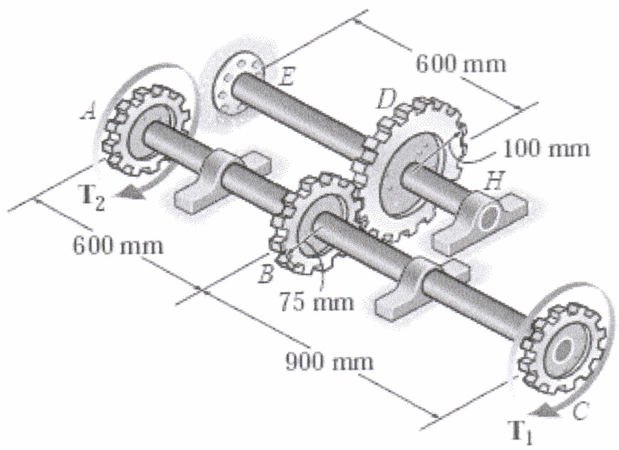


**Figure Q6**

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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*

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

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

*Power*

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

*Angle of twist*

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

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

*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*

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

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