Universiti Tun Hussein Onn Malaysia

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER I
## SESSION 2017/2018

| | | |
|---|---|---|
| COURSE NAME | : | SOLID MECHANICS 1 |
| COURSE CODE | : | BDA 10903 |
| PROGRAMME CODE | : | BDD |
| EXAMINATION DATE | : | DECEMBER 2017/JANUARY 2018 |
| DURATION | : | 3 HOURS |
| INSTRUCTION | : | PART A: ANSWER **THREE (3)** QUESTIONS **ONLY**<br>PART B: ANSWER **ALL** QUESTIONS |



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

**PART A (OPTIONAL):**
Answer **THREE (3)** questions **ONLY**.

**Q1.** (a) A horizontal rigid bar ABC of length 8 m is supported by inclined wire CD as shown in **Figure Q1(a)**. The wire is fastened to a support at D which a distance 3 m above point A. A uniform load of intensity 300 N/m at AB and the bar subjected to a load of 60 N. Calculate the internal reaction at the indicated section a-a for the structure shown.

(6 marks)

(b) The rigid block weighing 96 kN as shown in **Figure Q1(b)** is supported by three symmetrically placed rods. The lower ends of the rod were at the same level before the block was attached. The material physical properties of the steel rod and bronze rod are tabulated in **Table Q1(b)** and the temperature of all bars increase by 40 $^0$C.

(i) Determine the stress in the steel rod. (7 marks)

(ii) Determine the stress in the bronze rod (7 marks)

**Q2.** A simple overhanging beam AE as shown in **Figure Q2** carries two uniformly distributed loads and a concentrated load supported at the position indicated B and D.

(a) Draw the free body diagram for the beam.

(2 marks)

(b) Determine the support reaction at point B and D.

(4 marks)

(c) Construct the shear diagram.

(7 marks)

(d) Construct the moment diagram.

(7 marks)

**Q3.** The steel beam has the cross-sectional dimension area and subjected to the loading as shown in **Figure Q3.** Determine:-

(a) the maximum bending moment in the beam

(4 marks)

(b) the location of *C* (centroid) of the cross section where the neutral axis passes through.

(3 marks)

(c) the moment of inertia of the cross section

(5 marks)

(d) the maximum tensile and compressive stress in the beam.

(6 marks)

(e) Sketch the bending stress distribution on the cross section.

(2 marks)

**Q4.** The compound shaft shown in **Figure Q4** is attached to rigid supports. For the bronze segment AB, the maximum shearing stress is limited to 55 MPa and for the steel segment BC, it is limited to 83 MPa. For bronze, G = 44 GPa and for steel, G = 75 GPa. If a torque T=16270 Nm is applied as shown in the figure,

(a) Draw the free-body diagram of the shaft

( 1 mark)

(b) Write the equations of equilibrium about axis of shaft

(2 marks)

(c) Write the compatibility equation in terms of rotational displacement.

( 2 marks)

(d) Solve equilibrium and compatibility equations for unknown diameters

(10 marks)

(e) Solve equilibrium and compatibility equations for unknown torques

(5 marks)

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

**Q5.** A cylindrical pressure vessel with an inside diameter of 1.50 m is constructed by wrapping a 15 mm thick steel plate into a spiral and butt welding the mating edges of the plate as shown in **Figure Q5**. The butt welded seams form an angle of 30 $^0$C with a transverse lane through the cylinder and the internal pressure in the vessel is 1500 kPa.

(a) Determine the normal stress $\sigma_n$ perpendicular to the weld.

(10 marks)

(b) Determine the shearing stress $\tau_{nt}$ parallel to the weld.

(10 marks)

**Q6.** A propeller shaft subjected to combined torsion and axial thrust is designed to resist a shear stress of 700 kPa and a compressive stress of 560 kPa as shown in **Figure Q6**.

(a) Explain what is principal stress

(2 marks)

(b) Describe how principal stress can be calculated

(2 marks)

(c) Determine the principal stresses and show them on a sketch of a properly oriented element

(8 marks)

(d) Determine the maximum shear stresses and associated normal stresses and show them on a sketch of a properly oriented element

(8 marks)

**- END OF QUESTION –**

**FINAL EXAMINATION**

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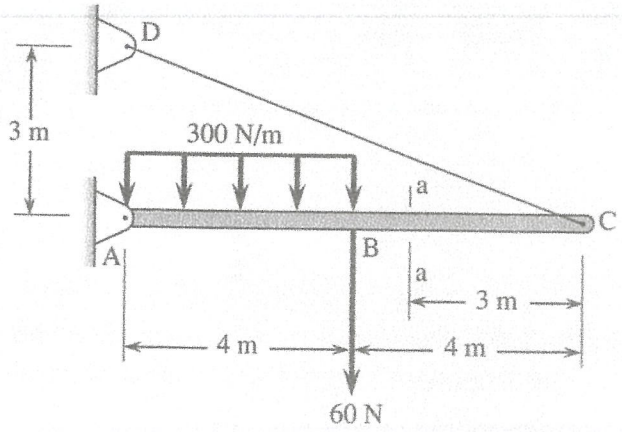


**Figure Q1 (a)**

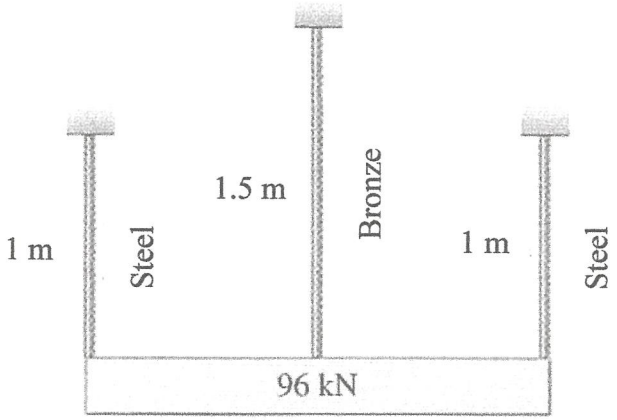


**Figure Q1 (b)**

**Table Q1(b)**

| | A ($mm^2$) | E (GPa) | α ( / $^0$C) |
|---|---|---|---|
| Each steel rod | 675 | 200 | 12 x $10^{-6}$ / $^0$C |
| Bronze rod | 1350 | 84 | 19 x $10^{-6}$ / $^0$C |

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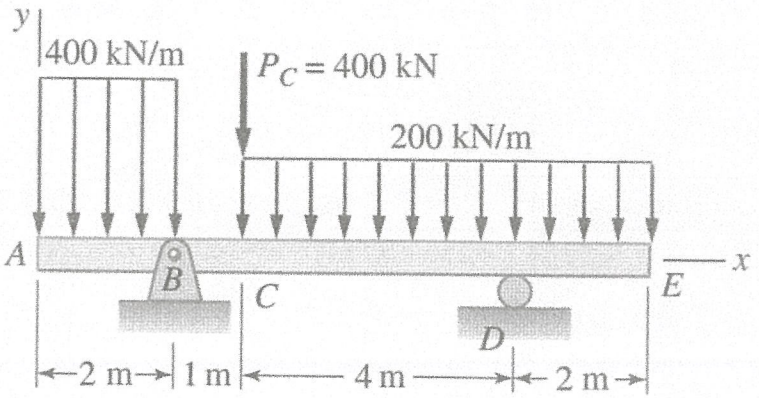


**Figure Q2**

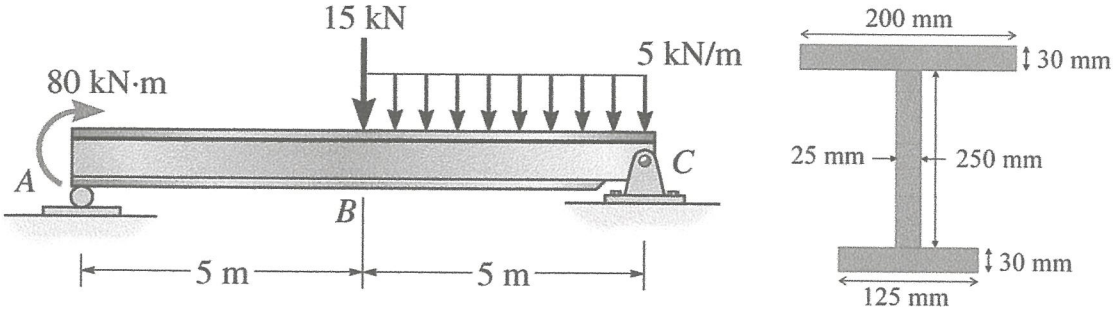


**Figure Q3**



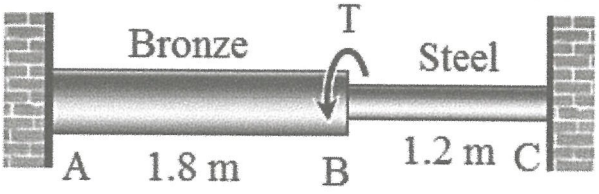


**Figure Q4**

FINAL EXAMINATION

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|---|---|---|---|
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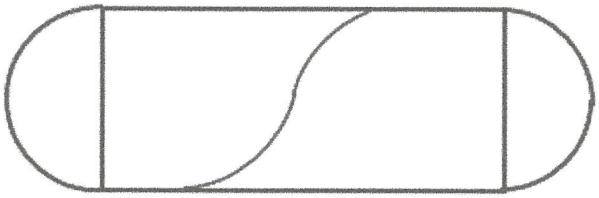

**Figure Q5**

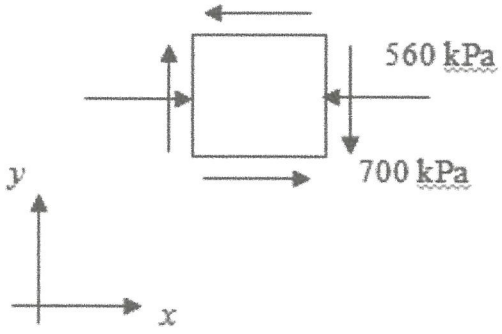


**Figure Q6**

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## EQUATIONS

$$\sigma_{ave} = \frac{P}{A} \qquad \delta = \sum_i \frac{P_i L_i}{A_i E_i}$$

$$\delta_T = \alpha(\Delta T)L \qquad n = \frac{E_2}{E_1}$$

$$\sigma_{ave} = \frac{\sigma_x + \sigma_y}{2} \qquad R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

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

$$\tan 2\theta_p = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$

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

$$\tau_{\max} = \frac{Tc}{J} \text{ and } \tau = \frac{T\rho}{J}$$

$$J = \tfrac{1}{2}\pi c^4 \qquad J = \tfrac{1}{2}\pi\left(c_2^4 - c_1^4\right)$$

$$\gamma_{\max} = \frac{\tau_{\max}}{G} = \frac{Tc}{JG} \qquad \phi = \sum_i \frac{T_i L_i}{J_i G_i}$$

$$T = \frac{P}{\omega} = \frac{P}{2\pi f} \qquad \tau_{\max} = \frac{T}{c_1 ab^2} \qquad \phi = \frac{TL}{c_2 ab^3 G}$$

$$\sigma_x = -\frac{My}{I} \qquad \frac{1}{\rho} = \frac{M}{EI}$$

$$\bar{Y} = \frac{\sum \bar{y}A}{\sum A} \qquad I_{x'} = \sum\left(\bar{I} + Ad^2\right)$$