

**UNIVERSITY COLLEGE TATI (UC TATI)****FINAL EXAMINATION QUESTION BOOKLET**

COURSE CODE	: BCE 2243
COURSE	: ENGINEERING MECHANICS
SEMESTER/SESSION	: 1-2024/2025
DURATION	: 3 HOURS

**Instructions:**

1. This booklet contains 4 questions. Answer **ALL** questions.
2. All answers should be written in answer booklet.
3. Write legibly and draw sketches wherever required.
4. If in doubt, raise your hands and ask the invigilator.

**DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO**

**THIS BOOKLET CONTAINS 6 PRINTED PAGES INCLUDING COVER PAGE**

**QUESTION 1**

a) The car in Figure 1 has a weight of 680 kg with the center of mass 1.5 m behind the front wheels of the car.

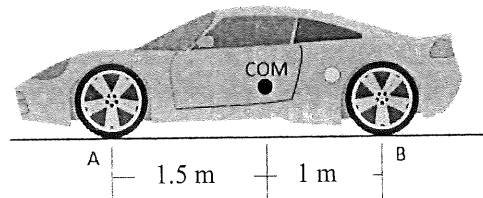


Figure 1

- i) Illustrate the free body diagram for the car. (3 marks)
- ii) Discover the equilibrium equations involved. (3 marks)
- iii) Use the equations in (ii) and solve the normal forces on the front wheels ( $F_F$ ) and the back wheels ( $F_B$ ) of the car. (7 marks)

b)

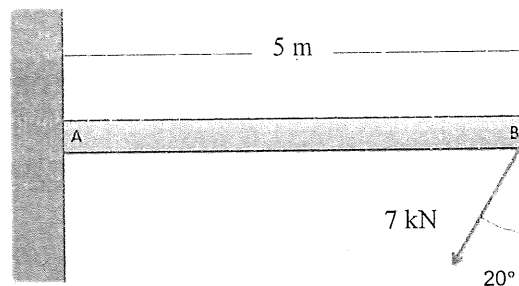


Figure 2

Figure 2 shows a 5-meter-long beam has a fixed connection to a wall at point A and a force acting (7 kN) as shown at point B.

- i) Illustrate the free body diagram for the beam. (2 marks)
- ii) Discover the equilibrium equations involved. (3 marks)
- iii) Solve the reaction forces acting at point A. (6 marks)

**QUESTION 2**

a)

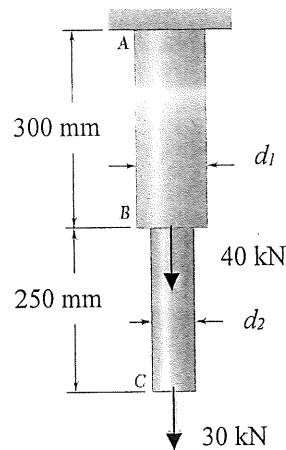


Figure 3

Figure 3 shows two solid cylindrical rods AB and BC are welded together at B and loaded as shown.

- i) Illustrate the free body diagram for AB and BC. (4 marks)
- ii) If the average normal stress must not exceed 175 MPa in rod AB and 150 MPa in rod BC, compute the smallest allowable values of  $d_1$  and  $d_2$  (in mm). (8 marks)
- iii) If  $d_1 = 50$  mm and  $d_2 = 30$  mm, discover the average normal stress at the midsection of rod AB and rod BC (in MPa). (8 marks)

b) A 60 m long steel wire is subjected to 6 kN tensile force. Knowing that  $E = 200$  GPa and that the length of the rod increases by 48 mm, compute:

- i. The smallest diameter that may be selected for the wire in mm
- ii. The corresponding normal stress in MPa.

(9 marks)

## QUESTION 3

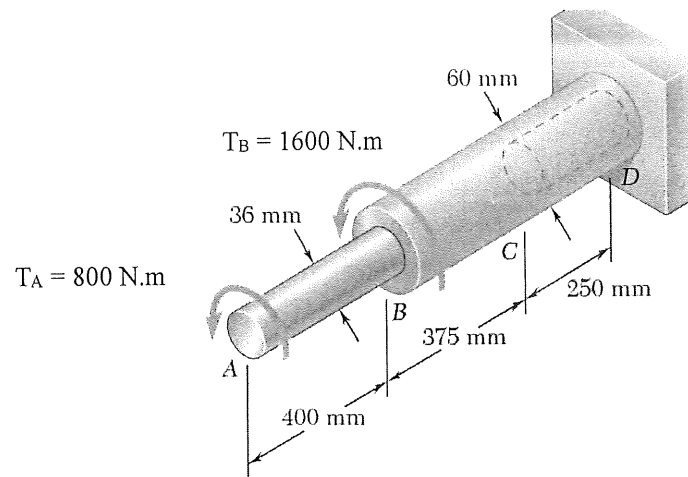


Figure 4

- a) Figure 4 shows the aluminum rod AB ( $G = 27 \text{ GPa}$ ) is bonded to the brass rod BD ( $G = 39 \text{ GPa}$ ). Knowing that portion CD of the brass rod is hollow and has an inner diameter of 40 mm, compute the angle of twist at A in ( $^\circ$ ).

(16marks)

- b) Solve the following:

- i) Compute the torque (in N.m) that can be applied to a solid shaft of 20 mm diameter without exceeding an allowable shearing stress of 80 Mpa.
- ii) Compute the torque (in N. m) if the solid shaft in (i) has been replaced by hollow shaft of the same cross sectional area and with inner diameter is 0.0058 m. Compute the torque (in N. m).

(9 marks)

**QUESTION 4**

Figure 5 shows the structure of beam and loading.

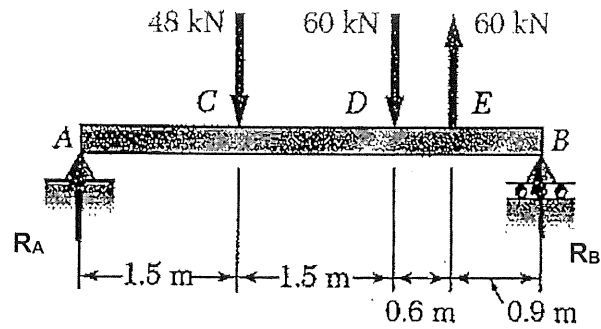


Figure 5

- Compute  $R_A$  and  $R_B$ . (10 marks)
- Construct the shear diagram for the beam. (6 marks)
- Construct the bending moment diagram for the beam. (6 marks)

-----End of question-----

## ATTACHMENTS

$$\sigma = \frac{P}{A} \quad \tau = \frac{V}{A} \quad FS = \frac{\sigma_u}{\sigma_{all}} = \frac{\text{ultimate stress}}{\text{allowable stress}} = \frac{\text{maximum stress}}{\text{working stress}}$$

$$A = \pi \frac{D^2}{4} \quad \delta = \frac{PL}{AE} \quad \epsilon = \frac{\delta}{L}$$

$$\sigma = E \epsilon \quad \delta = \sum \frac{P_i L_i}{A_i E_i} \quad E = \frac{\sigma_x}{\epsilon_x} \quad \nu = - \frac{\epsilon_y}{\epsilon_x}$$

$$\phi = \frac{TL}{JG} \quad \tau_{max} = \frac{T}{J} R_o$$

$$J = \int_0^R 2\pi\rho^3 d\rho = \frac{\pi R^4}{2} = \frac{\pi D^4}{32}$$

$$J = \int_{R_i}^{R_o} 2\pi\rho^3 d\rho = \frac{\pi(R_o^4 - R_i^4)}{2} = \frac{\pi(D_o^4 - D_i^4)}{32}$$