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UNIVERSITY EXAMINATIONS 2024/2025

SECOND YEAR FIRST SEMESTER EXAMINATION FOR DEGREE OF BACHELOR
OF TECHNOLOGY IN MECHANICAL ENGINEERING AND BACHELOR OF
TECHNOLOGY IN ELECTRICAL ENGINEERING

EMT 3204: SOLID AND STRUCTURAL MECHANICS 1

DATE: JANUARY 2025

TIME: 2 HOURS

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

- a) Briefly explain how simple tension and simple shear occurs in simple stress [2 marks]
- b) The following observations were made during a tensile test on a mild steel specimen 40 mm in diameter and 200 mm long.

Elongation with 40 kN load (within limit of proportionality) $\delta l = 0.0304$ mm

Yield load = 161 kN

Maximum Load = 242 kN

Length of specimen to fracture = 249 mm

Determine:

- Young's modulus of elasticity [3 marks]
 - Yield point stress [3 marks]
 - Ultimate stress [3 marks]
 - Percentage elongation [3 marks]
- c) A compound bar consists of a central steel strip which is 40 mm wide and 5 mm thick placed between two strips of brass each 40mm wide and x mm thick. The strips are firmly fixed together to form a compound bar of rectangular section 40 mm wide and (2x+5 mm) thick. Determine:



- i. The thickness of the brass strips which will make the apparent modulus of elasticity of the compound bar equal to $160 \times 10^3 \text{ MN/m}^2$. [10 marks]
 - ii. The maximum axial pull the bar can then carry if the stress is not to exceed 160 MN/m^2 , in either the brass or steel [6 marks]
- Take $E_s = 207 \text{ GN/m}^2$ and $E_b = 114 \text{ GN/m}^2$

QUESTION TWO (15 MARKS)

- a) Briefly explain the differences of the shaft arrangement in series and in parallel based on torque transmission [4 marks]
- b) A solid alloy shaft 50 mm diameter is to be coupled in series with a hollow steel shaft of the same external diameter. If the angle of twist per unit length of the steel shaft is to be 70 percent of that of the alloy shaft :
 - i. Find the internal diameter of the steel shaft [4 marks]
 - ii. Find the speed at which the shaft should be driven to transmit 20 kW if allowable shearing stresses in alloy and steel are 56 MN/m^2 and 80 MN/m^2 respectively.
Take modulus of rigidity of steel to be 2.25 times that of the alloy [7 marks]

QUESTION THREE (15 MARKS)

- a) A shaft is made from a tube. The ratio of the inside diameter to the outside diameter is 0.6. The material must not experience a shear stress greater than 500 kPa. The shaft must transmit 1.5 MW of mechanical power at 1500 rev/min. Calculate the shaft diameters. [6 marks]
- b) A thin steel tube 75 mm in diameter is 3 mm thick. If the allowable shear stress is 80 MN/m^2 and modulus of rigidity is 80 GN/m^2 , find:
 - i. Safe twisting moments that can be applied to the tubes [5 marks]
 - ii. The twist in a length of 600 mm [4 marks]

QUESTION FOUR (15 MARKS)

Two parallel walls are stayed together by a steel rod of 5 cm diameter passing through metal plates and nuts at both ends. The nuts are tightened, when the rod is at 150°C , to keep the walls 10 m apart. Determine the stresses in the rod when the temperature falls down to 50°C , if

(a) the ends do not yield [8 marks]

(b) the ends yield by 1 cm. [7 marks]

Take $E = 2 \times 10^5 \text{ N/mm}^2$ and $\alpha = 12 \times 10^{-6} \text{ K}^{-1}$.

QUESTION FIVE (15 MARKS)

A boiler shell is to be made of 15 mm thick plate having tensile stress of 120 MN/m^2 . If the efficiency of the longitudinal and circumferential joints are 70% and 30% respectively, determine:

i. Maximum permissible diameter of the shell for an internal pressure of 2 MN/m^2 [8 marks]

ii. Permissible intensity of internal pressure when the shell diameter is 1.5 m [7 marks]