60

MIE 221 (23-24)

(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS

2023/2024 ACADEMIC YEAR

SECOND YEAR FIRST SEMESTER EXAMINATIONS

FOR THE DEGREE

OF

BACHELOR OF BACHELOR OF SCIENCE IN MECHANICAL & INDUSTRIAL ENGINEERING

COURSE CODE: MIE 221

COURSE TITLE: SOLID MECHANICS I

DATE: 5/12/2023 **TIME: 8:00 AM – 10:00 AM**

INSTRUCTIONS TO CANDIDATES

1. This paper consists of **FOUR** questions
2. Answer Question **ONE (Compulsory)** and any other **TWO** Questions
3. All symbols have their usual meaning

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of 3 Printed Pages. Please Turn Over

MIE 221 (23-24)

QUESTION ONE **[30 marks]**

(a) (i) Find the maximum shearing stress in a propeller shaft 40 cm external, and 20 cm internal diameter, when subjected to a torque of 450 kNm.

(ii) If G = 80 GN/m^2, what is the angle of twist in a length of 20 external diameters?

(iii) What diameter would be required for a solid shaft with the same maximum stress and torque? ***[9 marks]***

(b) Define the terms: Elasticity, elastic limit, Youngs Modulus and modulus of rigidity. ***[3 marks]***

(c) A cylinder has an internal diameter of 230 mm, has walls 5 mm thick and is 1 m long. It is found to change in internal volume by 12.0×10^{-6} m^3 when filled with a liquid at a pressure *P*. If E = 200 GPa and v = 0.25, and assuming rigid end plates, determine:

i. the values of hoop and longitudinal stresses.

ii. the modifications to these values if joint efficiencies of 45 % (hoop) and 85 % (longitudinal) are assumed.

iii. the necessary change in pressure p to produce a further increase in internal volume of 15 %. The liquid may be assumed incompressible. ***[8 marks]***

(d) Draw, with the help of a graph paper, the shear force and bending moment diagram for the beam which is loaded as follows, 9 kN point load, 30 kN point load, 69 kNm couple and 15 kN point load at A, C, D and E respectively as shown in Fig. Q1(d). The beam is held on points B and D.

[10 marks]

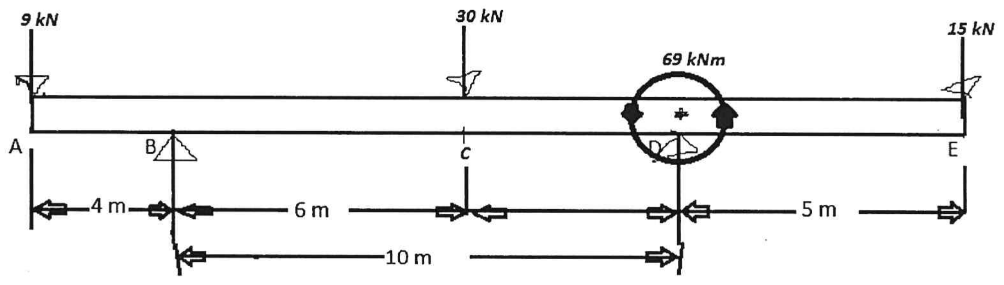


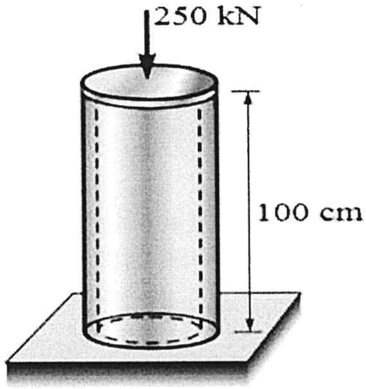
Fig Q 1 (d)

QUESTION TWO **[20 marks]**

a) Distinguish between the following, giving due explanation and their unit dimensions.

(i) Stress and strain,
(ii) Force and stress and
(iii) Tensile stress and compressive stress. **[3 marks]**

(b) A short post constructed from a hollow circular tube of aluminum supports a compressive load of 250 kN (see FIG. Q2 (b)). The inner and outer diameters of the tube are d1 = 9 cm and d2 = 13 cm, respectively, and its length is 100 cm. The shortening of the post due to the load is measured as 0.5 mm. Determine the compressive stress, strain and Young's Modulus of the material in the post. (Disregard the weight of the post itself, and assume that the post does not buckle under the load). **[10 marks]**



Hollow aluminum post in compression

Fig Q 2. (b)

(c) A wood beam with the allowable bending stress = 12 MPa is subjected to a uniformly distributed load of constant intensity q. The beam is supported by a pin at one end and a roller at a distance of 4 m from the pin. The beam has a rectangular cross-section with a width of b = 250 mm and a height of h = 325 mm. Determine the maximum permissible value of q (in kN/m). ***[7 marks]***

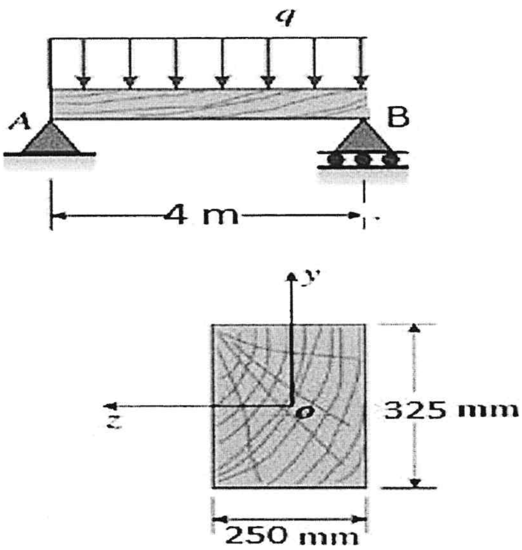


Fig Q 2 (c)

QUESTION THREE [20 marks]

(a) Prove that maximum shear stress at any point in a thin cylinder, subjected to internal fluid pressure is given by,

$$Max. Shear\ stress = \frac{pxd}{8t}$$

Where p = internal fluid pressure,
d = internal dia. of thin cylinder and
t = wall thickness of cylinder. **[5 marks]**

(b) A cylinder is 150 mm mean diameter and 750 mm long with a wall 2 mm thick. It has internal pressure 0.8 MPa greater than the outside pressure. Calculate the following.
- (i) The circumferential strain.
- (ii) The longitudinal strain.
- (iii) The change in cross sectional area.
- (iv) The change in length.
- **(v)** The change in volume. **[15 marks]**

Take E = 200 GPa and υ = 0.25

QUESTION FOUR [20 marks]

The following (**Table Q4**) engineering stress-strain data were obtained at the beginning of a tensile test for 0.2% C plain-carbon steel.

Engineering Stress (MPa)	*Engineering Strain (m/m)*
0	0
103.44	0.0005
206.85	0.01
275.80	0.0015
344.75	0.002
413.70	0.0035
455.07	0.004
482.65	0.006
496.44	0.008

TABLE Q4

a) Plot the engineering stress-strain curve for these data. **[10 marks]**

b) Determine the 0.2 percent offset yield stress for this steel. **[2 marks]**

c) Determine the tensile elastic modulus of this steel. **[2 marks]**

d) State Hooke's Law and explain how it relates to the stress-strain curve in the elastic region. **[3 marks]**

e) How does a material's behavior deviate from Hooke's Law beyond the elastic region? **[3 marks]**