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MIE 321 (23-24)

(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS

2023/2024 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER EXAMINATIONS

FOR THE DEGREE

OF

BACHELOR OF SCIENCE IN MECHANICAL & INDUSTRIAL ENGINEERING

COURSE CODE: MIE 321

COURSE TITLE: SOLID MECHANICS III

DATE: 5/12/2023 **TIME: 12:00 PM – 2:00 PM**

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

QUESTION ONE [30 marks]

(a) A horizontal rectangular steel strut is used in a design of a 3 m long engine part having pin joints at its ends. Determine the maximum stress induced in the strut when fully loaded with an axial thrust of 180 kN and a vertical spread load of 20 kN/m length as shown Fig Q1. below. The cross-sectional dimensions of the strut are 50 mm wide and 90 mm deep. Take E = 210 GPa. ***[10 marks]***

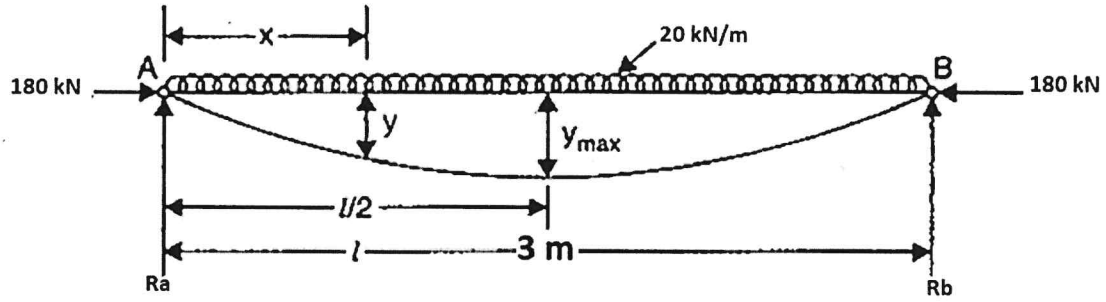

Fig. Q 1.(a)

(b) A thermostat operates by utilizing a bimetallic strip, which consists of two different metals bonded together. The metals have different coefficients of thermal expansion. As the temperature changes, the strip will bend due to the differential expansion or contraction of the metals.

(i) Explain the working principle of a bimetallic strip thermostat. How do changes in temperature lead to the deflection of the strip?

(ii) In designing a compact thermostat, one might consider the concept of "minimum volume." Discuss the challenges and considerations a designer might face when trying to minimize the volume of a thermostat without compromising its performance." ***[10 marks]***

(c) A beam of I-section shown in Fig Q 1 (c) is simply supported over a span of 4 m. Determine the load that the beam can carry per meter length, if the allowable stress in the beam is 40 MPa. ***[10 marks]***

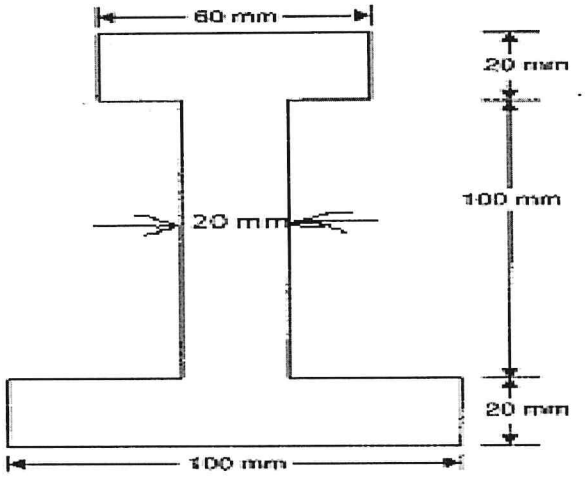

Fig Q. 1 (c)

QUESTION TWO **[20 marks]**

a) A timber beam is 15 cm deep by 10 cm wide, and carries a central load of 30 kN at the center of a 3 m span; the beam is simply-supported at each end. The timber is reinforced with flat steel plates 10cm wide by 1.25 cm thick bolted to the upper and lower surfaces of the beam. Taking E for steel as 200 GN/m^2 and G for timber as 1 GN/m^2, estimate

i. the maximum direct stress in the steel strips,

ii. the average shearing stress in the timber,

iii. the shearing load transmitted by the bolts,

iv. the deflection at the center of the beam ***[10 marks]***

b) Apply Castigliano's second theorem to compute the deflection of the beam at C for the beam in Fig Q 2(b). Take E = 200 GPa and I = 8.6×10^{-4} m^4 . ***[10 marks]***

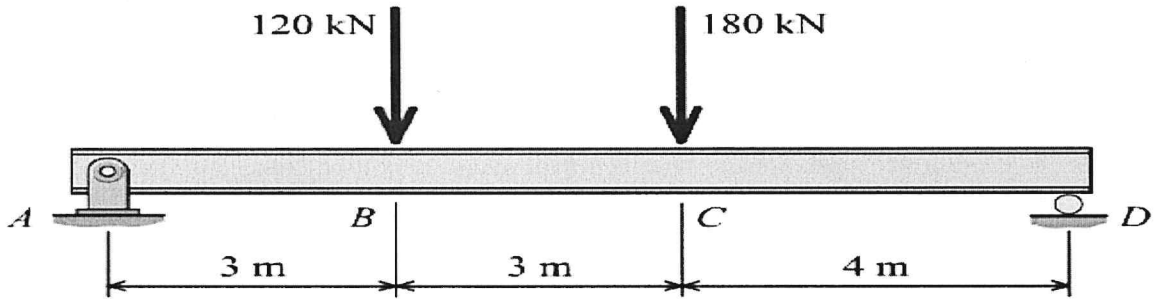

Fig Q 2(b)

QUESTION THREE [20 marks]

(a) Explain the following terms:

(i) Proof stress

(ii) Proof resilience

(iii) Modulus of resilience *[3 marks]*

(b) A rod 15 mm in diameter is stretched 4.2 mm under a steady load 20 kN. What stress would be produced in the bar by a weight of 900 N, falling through 90 mm before commencing to stretch, the rod being initially unstressed? The value of E = 210 GPa.

[6 marks]

(c) A load of 200 N falls through a height of 5 cm onto a collar rigidly attached to the lower end of a vertical bar 3 m long and of 2.5 cm^2 cross-sectional area. The upper end of the vertical bar is fixed. Determine:

(i) Maximum instantaneous stress induced in the vertical bar

(ii) Maximum instantaneous elongation, and

(iii) Strain energy stored in the vertical rod. *[11 marks]*

QUESTION FOUR [20 marks]

(a) Prove that the crippling load by Euler's formula for a column having on end fixed and another end free is given by

$$P = \frac{\pi^2 EI}{4l^2}$$

Where l = actual length of the column,

E = Young's modulus, and

I = least moment of inertia. *[10 marks]*

(b) A column of circular section is subjected to a load of 200 kN. The load is parallel to the axis but eccentric by an amount of 3 mm. The diameters of the column are 70 mm and 35mm external and internal respectively. If both ends of the column are hinged and the column is 3 m long, then determine the maximum stress in the column. Take E = 210 GPa. *[10 marks]*

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