



MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 303: SOLID AND STRUCTURAL MECHANICS II

DATE: 24/3/2021

TIME: 2.00-4.00 PM

INSTRUCTIONS

This paper contains FIVE questions

Question ONE is compulsory and carries 30 Marks while the rest carries 20 Marks each. Attempt any two.

QUESTION ONE (30 MARKS)

- a) Starting from the first principles, derive the simple bending equation (6 marks)
- b) Using sketches, distinguish between uniformly varying load, uniformly distributed load and point load (4 marks)
- c) What is the principle of virtual work? (2 marks)
- d) What do you understand by determinate and indeterminate structures? (4 marks)
- e) Describe any four industrial uses of springs. (4 marks)
- f) A composite spring has two close-coiled helical springs connected in series. One spring is made of steel with a mean coil diameter of 22 mm, wire diameter 3 mm and has 15 coils. The other spring is made from bronze with a mean coil diameter of 26 mm and a wire diameter of 2.6 mm, and has 10 coils. If $G_{st} = 80$ GPa and $G_{br} = 40$ GPa, Calculate
 - i. The stiffness of the composite spring (3 marks)

- ii. The greatest load that can be carried by the composite spring if the maximum allowable stresses are 240 MPa and 160 MPa in the steel and bronze respectively (3 marks)
- iii. The corresponding extension (2 marks)
- iv. The strain energy in the composite spring (2 marks)

QUESTION TWO (20 MARKS)

- a) Fig 2 (a) shows a timber beam 80 mm x 120 mm reinforced by two similar steel plates of cross-section 6 mm x 80 mm. Calculate:
- i. The moment of resistance of the reinforced beam if the maximum stress in the timber is limited to 7.4 MN/m^2 and that in the steel to 150 MN/m^2 (4 marks)
 - ii. The maximum uniformly distributed load that the beam can carry on a simply supported span of 6 m. Assume $E_{\text{steel}} = 200 \text{ GPa}$ and $E_{\text{timber}} = 10 \text{ GPa}$ (4 marks)

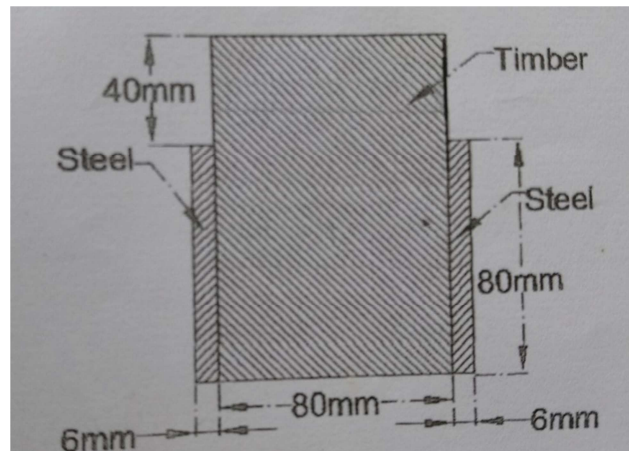


Fig. Q 2 (a)

- b) A light-alloy I-beam of 10 cm overall depth has flanges of overall breadth 5 cm and thickness 0.625 cm as shown in Fig 2(b), the thickness of the web is 0.475 cm. If the bending stresses are not to exceed 160 MN/m^2 in tension and compression estimate the greatest moments which may be applied about the principal axes of the cross-section. (8 marks)

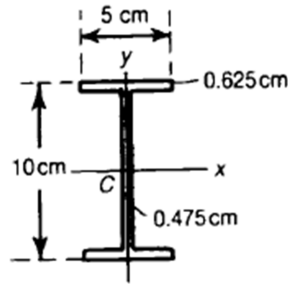


Fig. Q 2 (b)

QUESTION THREE (20 MARKS)

- a) Derive the flexural formula for a composite beam (6 marks)
- b) A beam of length 7 m is simply supported at two positions, one at 1m from the left hand and the other at 2 m from the right hand end as shown in Fig Q3 (b). The cross-section of the beam is a hollow rectangle as shown. The beam is subjected to a uniformly distributed load including its own weight of intensity 4 kN/m over its entire length, together with concentrated loads of 7 kN at the left hand end and 9 kN at 1m from the right hand end. Draw the shear force and bending moment diagram and use them to determine:
 - i. The magnitude of the greatest shear force. (6 marks)
 - ii. The magnitude and position of the greatest bending moment. (6 marks)
 - iii. The greatest bending stress (2 marks)

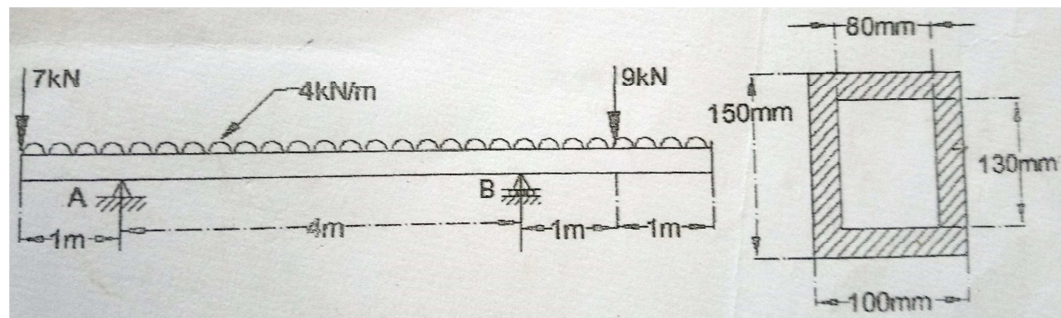


Fig Q3 (b)

QUESTION FOUR (20 MARKS)

- a) State two reasons why deflection of beams is undesirable in engineering practice (2 marks)
- b) Prove that the basic differential equation for the deflection of beams is given by the following equation;

$$EI \frac{d^2v}{dx^2} = -M \quad (6 \text{ marks})$$

- c) The simply supported beam shown in Fig Q4 (b) is subjected to a uniform load of intensity q acting throughout the span of the beam. The beam has length L and constant flexural rigidity. Determine:
- The equation of the deflection curve. (8 marks)
 - The maximum deflection, δ_{max} . (2 marks)
 - The angle of rotation θ_A at the support A and θ_B at the support B. (2 marks)

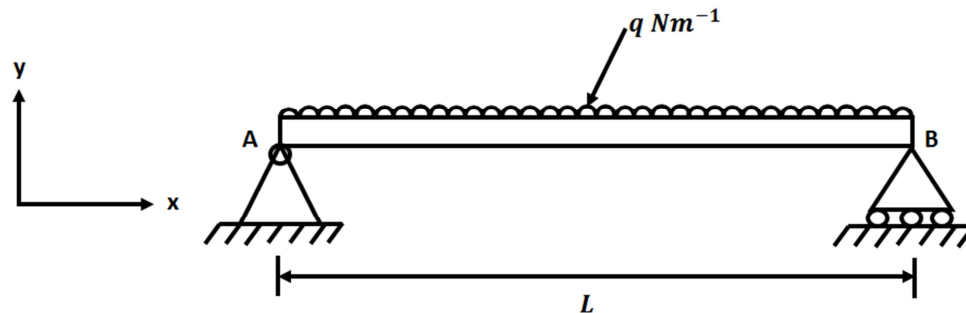


Fig. Q4 (b)

QUESTION FIVE (20 MARKS)

- Define what is a composite beam and give an example (2 marks)
- State why sometimes it is necessary to use composite beams instead of simple beams (2 marks)
- Define the Macaulay's method of beam deflection (2 marks)
- Use unit load method to find the deflection at the center of the beam shown in Fig. Q 5(a).
Take: $E = 0.21 \text{ GPa}$ and $I = 410 \times 10^6 \text{ mm}^4$ (14 marks)

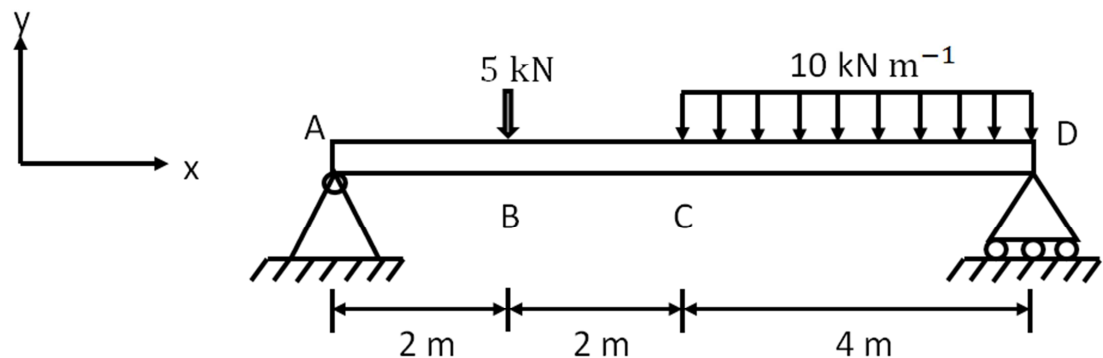


Fig Q5 (d)