MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR SPECIAL/SUPPLIMENTARY 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 M N/m^2 and that in the steel to 150 M N/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_{steel} = 200 GPa and E_{timber} = 10 GPa (4 marks)

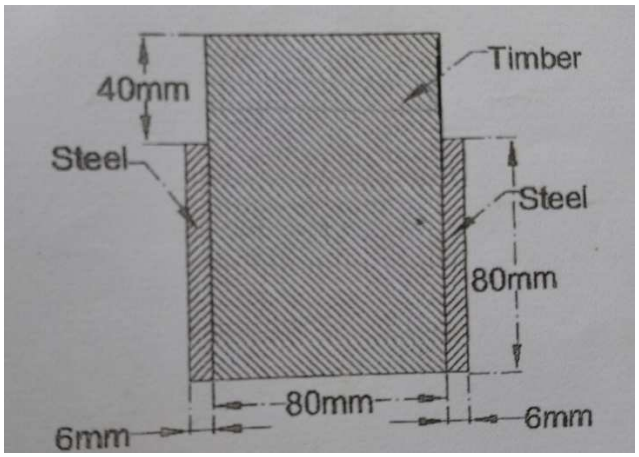

Fig. Q 2 (a)

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)

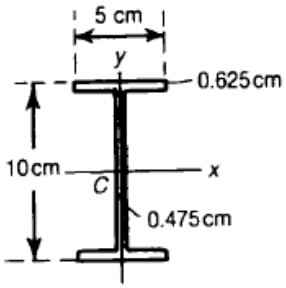

Fig. Q 2 (b)

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)

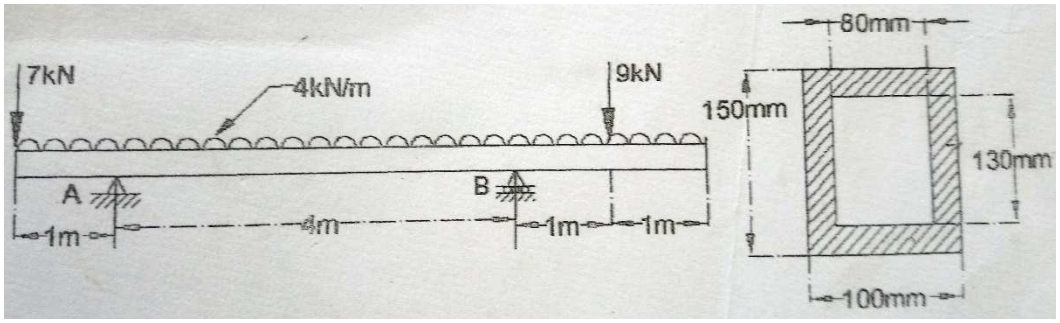

Fig Q3 (b)

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;

$$EI\frac{d^2v}{dx^2} = -M$$ (6 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:

i. The equation of the deflection curve. (8 marks)

ii. The maximum deflection, ∂_{max}. (2 marks)

iii. The angle of rotation θ_A at the support A and θ_B at the support B. (2 marks)

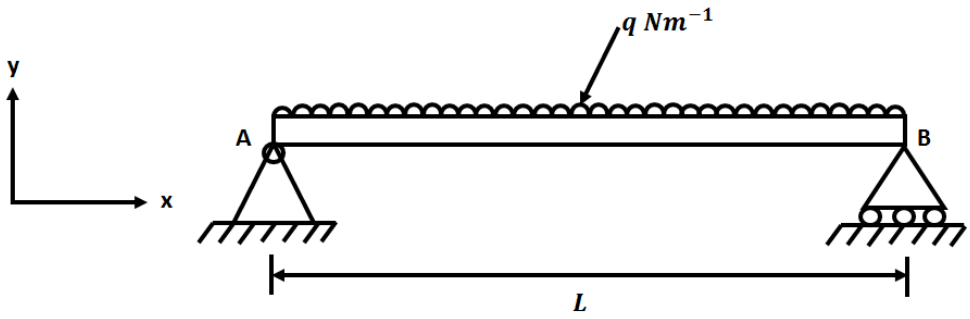

Fig. Q4 (b)

QUESTION FIVE (20 MARKS)

a) Define what is a composite beam and give an example (2 marks)

b) State why sometimes it is necessary to use composite beams instead of simple beams (2 marks)

c) Define the Macaulay's method of beam deflection (2 marks)

d) Use unit load method to find the deflection at the center of the beam shown in Fig. Q 5(a). Take: $E = 0.21$ GPa and $I = 410 * 10^6$ mm^4 (14 marks)

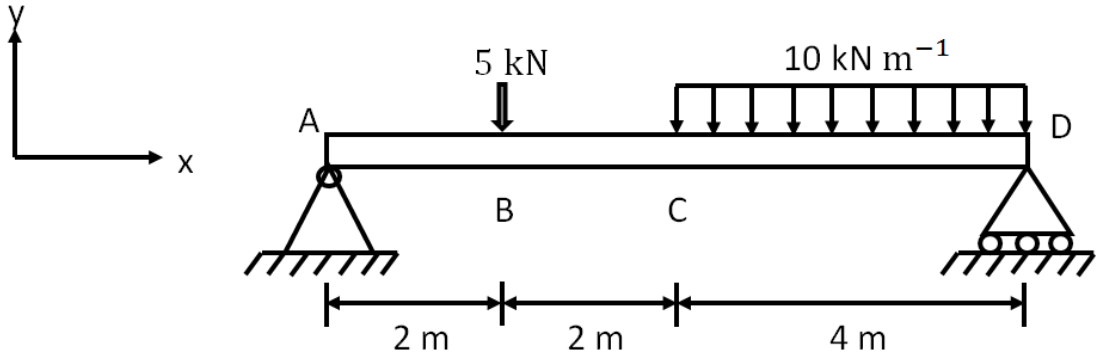

Fig Q5 (d)