MACHAKOS UNIVERSITY

University Examinations for 2022/2023

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR SECOND SEMESTER EXAMINATIONS FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 303: SOLID AND STRUCTURAL MECHANICS 11

DATE: **TIME:**

INSTRUCTIONS:

This paper contains FIVE questions

Question ONE is **compulsory** and carries 30 Marks.

Questions TWO – FIVE carries 20 Marks each. **Answer any Two.**

QUESTION ONE (COMPULSORY) (30 MARKS)

a) A horizontal beam AB 6 m long is hinged at point A and freely supported at B and subjected to forces as shown in Fig Q 1 a).

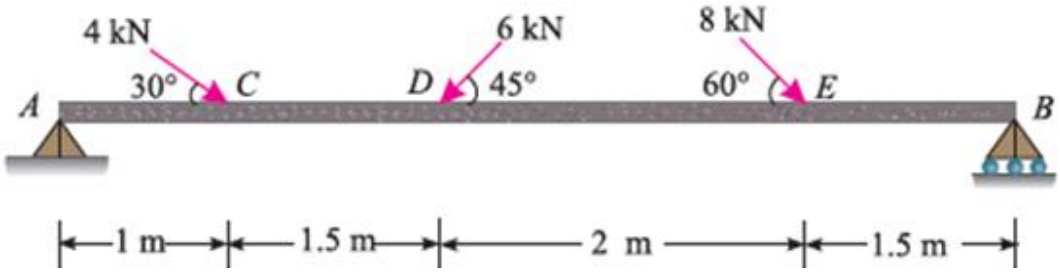

Fig. Q 1 a)

i) Determine all the reactions of the beam (3 marks)

ii) Sketch the shear force diagram for the beam indicating the forces. (2 marks)

b) A beam of length 15 m, Fig. Q 1 b), carries a uniformly varying load of intensity 30 N for every unit metre length at the right end. Determine the reactions of the beam to this load.

(4 marks)

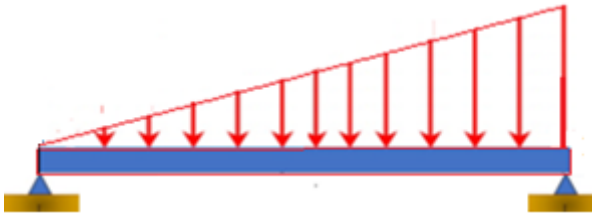

Fig. Q 1 b)

c) A beam diameter d (m) is subjected to a positive bending moment M (N-m). Starting from first principles, show that at maximum stress;

$$\frac{2\sigma}{d} = Ek = \frac{64M}{\pi d^4}$$ (6 marks)

Where σ is flexural stress, E is Young's Modulus and k is curvature.

d) A circular shaft of diameter d mm and length L mm is loaded at the free end by a vertical force W as shown in Fig. Q 1 d).

Fig. Q 1 d)

Starting from first principles, show that the deflection equation will be determined from:

$$EI\frac{d^2y}{dx^2} = W(x - L)$$ (7 marks)

Where E, I retain their special meanings and x is a random distance measured from the fixed support.

e) A beam 5 m long shown in Fig Q1 e) is loaded by an inclined load of 10 kN. If the angle of inclination θ is 38.87^0; and the breadth and height are 200 mm and 300 mm respectively;

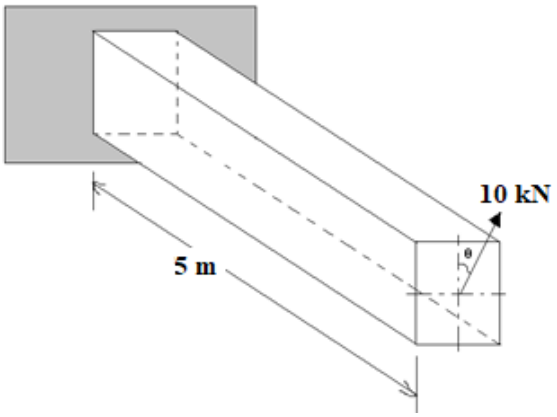

Fig. Q 1 e)

i) Find the orientation of the neutral axis (2 marks)

ii) Calculate the maximum stress in the beam (3 marks)

f) A leaf spring is to be made from seven steel plates 65 mm wide and 8 mm thick. Calculate the length of the spring, so that it may carry a central load of 4 kN, the bending stress being limited to 120 MPa. Also calculate the deflection at the centre of the spring.

Take E for the spring material as 200 GPa. (3 marks)

QUESTION TWO (20 MARKS)

a) The composite beam shown in Fig. Q 2 a) below is formed from a wood beam measuring 4.0 cm by 6.0 cm and steel reinforcing plate 4.0 cm wide and 0.5 cm thick. The beam is subjected to a positive bending moment of 60 kN-m. Using the transformed section method, calculate the largest tensile and compressive stresses in the wood and the maximum and minimum tensile stresses in the steel if the Young's Moduli of wood and steel are 10 MPa and 200 GPa respectively. (10 marks)

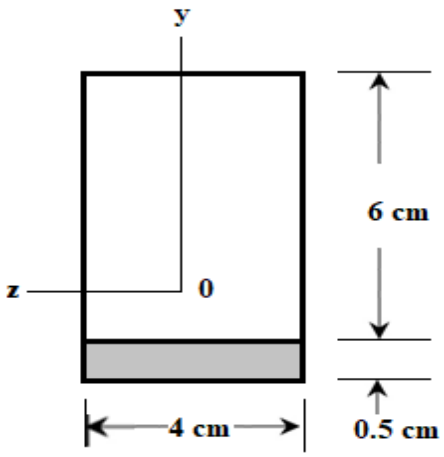

Fig. Q 2 a)

b) Fig Q2 b) shows a statically indeterminate pin-jointed frame where all members remain elastic, have the same Young's Modulus E and cross-sectional area a. If there are no initial lacks of fit of the members find the force in the member AC using the Principle of Virtue Work. . (10 marks)

Take member AC as the redunant frame

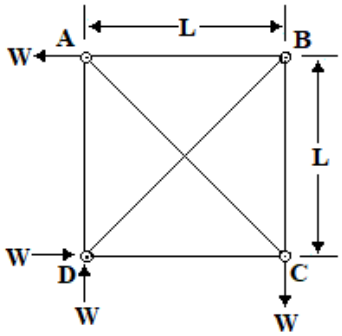

Fig. Q 2 b)

QUESTION THREE (20 MARKS)

A simply supported beam is loaded as shown in Fig. Q 3) and is made of timber with an allowable bending stress $\sigma_{all} = 12\ MPa$. The beam has a rectangular cross section with depth = twice the breadth. Determine

a) The reaction forces at the supports (3 marks)

b) Draw the shear force and bending moment diagrams for the beam (12 marks)

c) The optimum dimensions of the beam (5 marks)

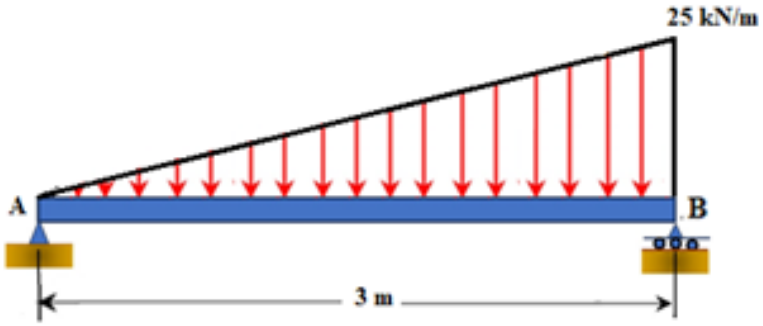

Fig. Q3)

QUESTION FOUR (20 MARKS)

The beam shown in Fig. Q 4) is made up of steel. If the allowable shear stress is 35 MPa;

a) Check the suitability of the section (16 marks)

b) If you designed such a structure assuming that the web carries all the shear stress, what percentage error would you get? (4 marks)

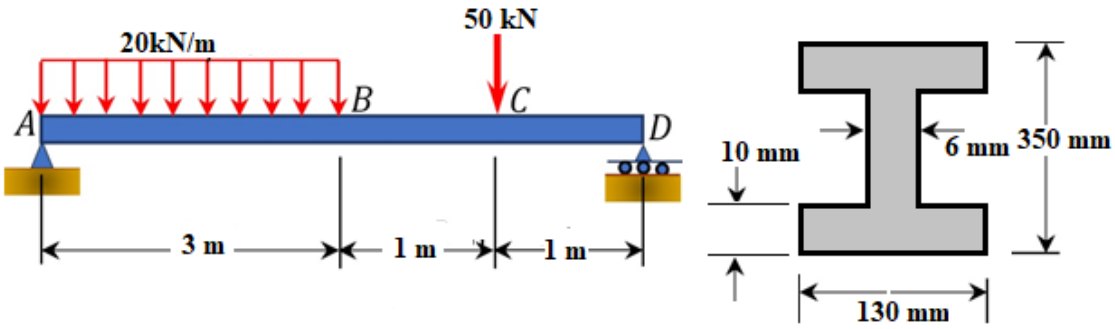

Fig. Q 4)

QUESTION FIVE (20 MARKS)

A simply supported horizontal beam is loaded with a concentrated load, a uniformly distributed load and a bending moment as shown in Fig Q 5). The beam has a solid rectangular cross-section 100 mm breadth and 450 mm deep. The Young's Modulus E is 200 GPa. Determine

a) The reaction forces at the supports (4 marks)

b) The expression for the elastic curve and slope using singularity functions (12 marks)

c) The deflection and slope at the centre of the beam (4 marks)

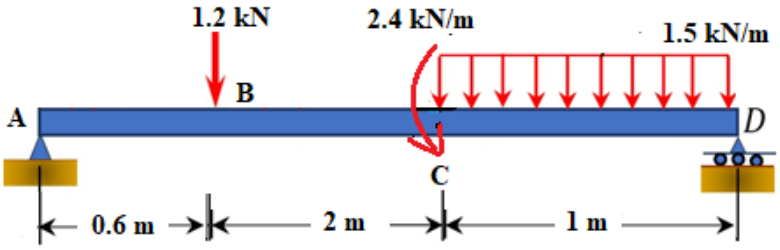

Fig. Q 5)