MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 303: SOLID AND STRUCTURAL MECHANICS II

DATE: 17/5/2019 **TIME: 8.30-10.30 AM**

INSTRUCTIONS:

1. ***QUESTION ONE*** *is* ***COMPULSORY*** *and contains* ***30 MARKS****. The remaining* ***FOUR*** *questions contain* ***20 MARKS*** *each.*
2. *All symbols have usual meaning unless otherwise stated*
3. *Use* ***CLEAR****,* ***NEAT*** *and* ***WELL-LABELLED*** *sketches*

QUESTION ONE (30 MARKS)

a) With the aid of well-labelled diagrams, highlight four types of springs. (2 marks)

b) Explain four applications of springs. (4 marks)

c) An open coiled helical of 10 coils manufactured from a wire of 6 mm diameter has a mean diameter of 76 mm and a helix angle of 20°. Determine:

i. The load required to produce an extension of 8 mm on the spring. (4 marks)

ii. The bending and shear stresses in the surface of the wire due to the above extension? (7 marks)

iii. The angular twist at the free end of the above spring when subjected to an axial torque of 1.5 N m? (3 marks)

You may use the following constants and relations for the spring material:

E = 210 GPa and G = 70 GPa.

$$\delta = 2\pi nWR^3 \sec\alpha\left[\frac{\cos^2\alpha}{GJ} + \frac{\sin^2\alpha}{EI}\right] \quad \text{and} \quad \theta = 2\pi nRT \sec\alpha\left[\frac{\sin^2\alpha}{GJ} + \frac{\cos^2\alpha}{EI}\right]$$

d) With the aid of diagrams, explain the various sign conventions used for shear force and bending moment. (2 marks)

e) Using a diagram, define the term point of contraflexure. (2 marks)

f) The beam shown in Fig. Q 1 (f) is loaded with a combination of concentrated and uniformly distributed loads. Suppose the point of inflection occurs between C and D, find its location from point C. (3 marks)

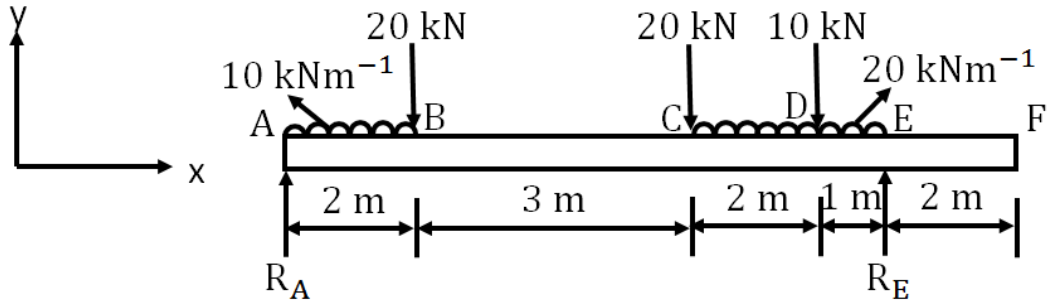

Fig. Q 1 (f)

g) A beam is subjected to a slowly moving load. Highlight two assumptions used in the analysis of such a beam. (2 marks)

h) Write down the basic differential equation for the deflection of beams. (1 mark)

QUESTION TWO (20 MARKS)

a) A steel bar of rectangular cross-section, 10 cm deep and 5 cm wide, is bent in the planes of the longer sides. Estimate the greatest allowable bending moment if the bending stresses are not to exceed 150 GPa in tension and compression. (4 marks)

b) The simply supported beam shown in Fig Q 2 (a) 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)

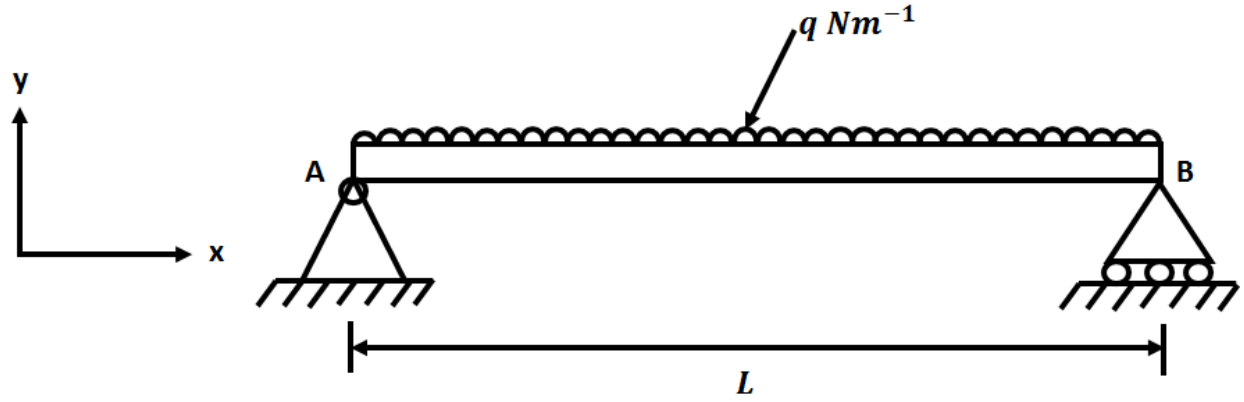

Fig. Q 2 (a)

c) Suppose $q = 5000\ \text{Nm}^{-1}$, calculate the flexural stiffness which limits the deflection to 2 mm at the mid span of the beam. (4 marks)

QUESTION THREE (20 MARKS)

a) State the principle of virtual work. (2 marks)

b) With the aid of well labelled diagrams, differentiate between determinate and indeterminate structures. (4 marks)

c) Use unit load method to find the deflection at the center of the beam shown in Fig. Q 3 (c). Take: $\text{E} = 0.2\ \text{GPa}$ and $\text{I} = 400 * 10^6\ \text{mm}^4$. (14 marks)

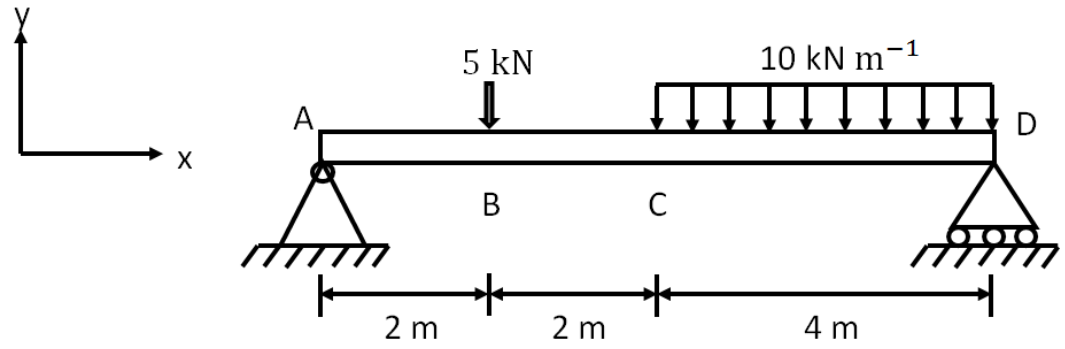

Fig. Q 3 (c)

QUESTION FOUR (20 MARKS)

a) Construct the shearing force and bending moment diagrams for the beam shown in Fig. Q 4 (b). (13 marks)

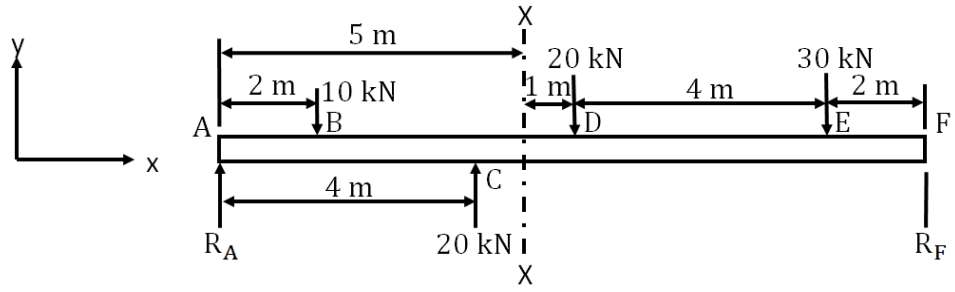

Fig. Q 4 (b)

b) A timber joist 15 cm by 7.5 cm has reinforcing steel flange plates 1.25 cm thick as shown in Fig. Q 4 (a). The composite beam is 3 m long, simply-supported at each end and carries a uniformly distributed lateral load of 10 kN. Taking $\frac{E_s}{E_t} = 20$, Estimate:

i. The maximum bending stresses in the steel and timber. (5 marks)

ii. The intensity of the shearing force transmitted between the steel plates and the timber. (2 marks)

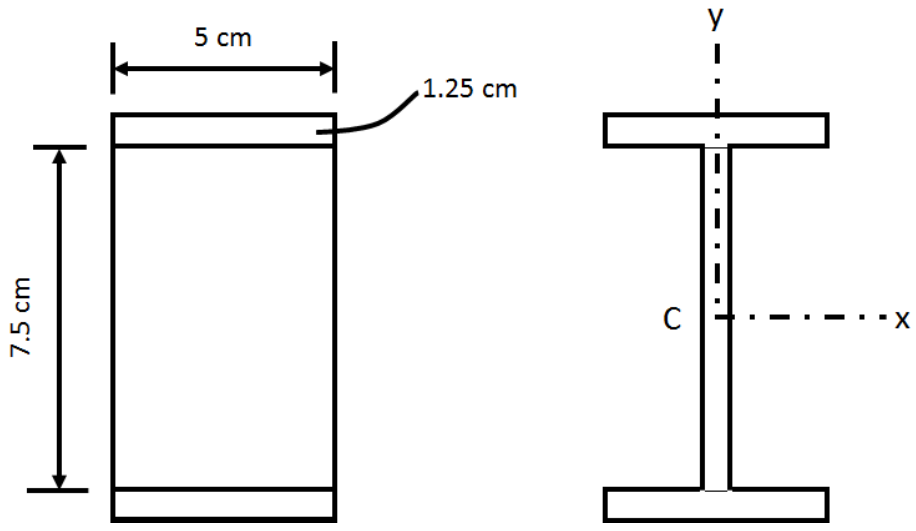

Fig. Q 4 (c)

QUESTION FIVE (20 MARKS)

a) When a linear-elastic cantilever of variable section carries an end load *W,* the deflected form is:

$$y = W\left[a\left(\frac{x}{L}\right)^2 + b\left(\frac{x}{L}\right)^3\right]$$

where a and b are constants. Using the reciprocal property of linear elastic systems, estimate:

i. The deflection of the free end of the cantilever when it carries a uniformly distributed lateral load of intensity *w*. (3 marks)

ii. If the linear-elastic beam above carries a couple *M* at the free-end, estimate the vertical deflection of the free-end. (4 marks)

b) Suppose a single concentrated vertical load *W* travels slowly along a beam *BC,* which is simply-supported at each end as shown in Fig. 5 (b). If a is the distance of the load from B, determine:

i. The reactions at B and C respectively. (2 marks)

ii. The bending moments at a distance z from B when $z < a$ and $z > a$. (2 marks)

iii. The greatest bending moment which can occur at a section z from B. (3 marks)

iv. The shearing force at a distance z from B when $z < a$ and $z > a$. (1 mark)

v. The greatest positive and negative shearing force in the beam. (3 marks)

vi. Sketch the bending moment and shear force diagrams for the beam. (2 marks)

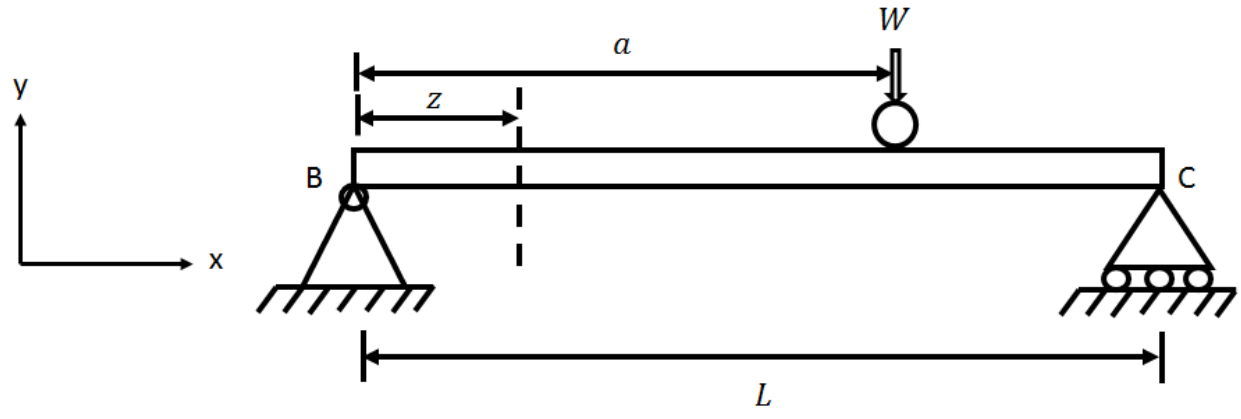

Fig. Q 5 (b)