MACHAKOS UNIVERSITY

University Examinations 2018/2019

THIRD YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN MECHANICAL AND MANUFACTURING ENGINEERING

EMM 303: SOLID AND STRUCTURAL MECHANICS II

DATE: MAY 2019 TIME:2 HOURS

INSTRUCTIONS

1. This examination contains **FIVE** questions
2. You are required to attempt **THREE** questions.
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:

$$E = 210 \text{ GPa and } G = 70 \text{ GPa.}$$

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

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]

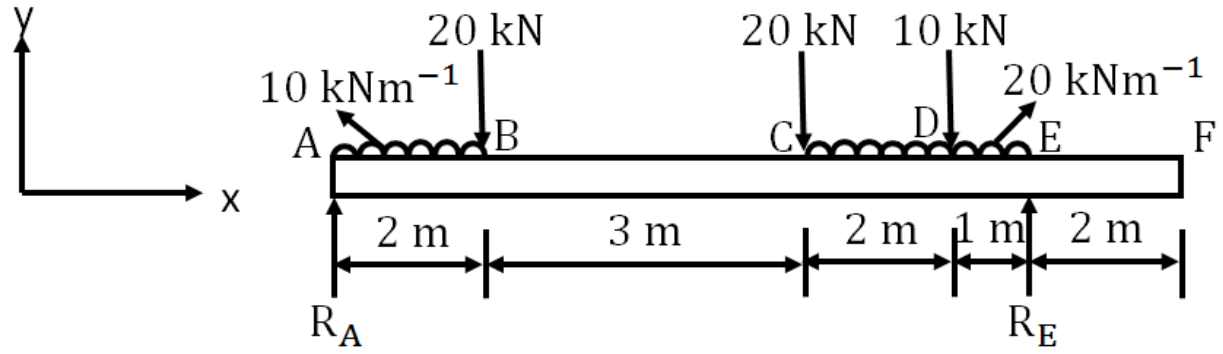

Fig. Q 1 (f)

g. A beam is subjected to a slowly moving load. Highlight two assumptions used in the analysis of such a beam. [2 mark]

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]

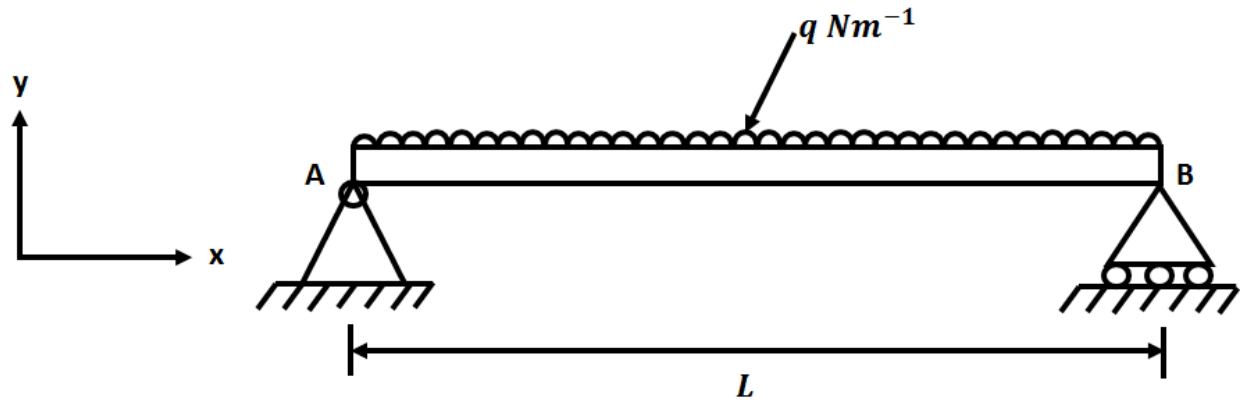

Fig. Q 2 (a)

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: $\text{E} = 0.2$ GPa and $\text{I} = 400 * 10^6\ \text{mm}^4$. [14 marks]

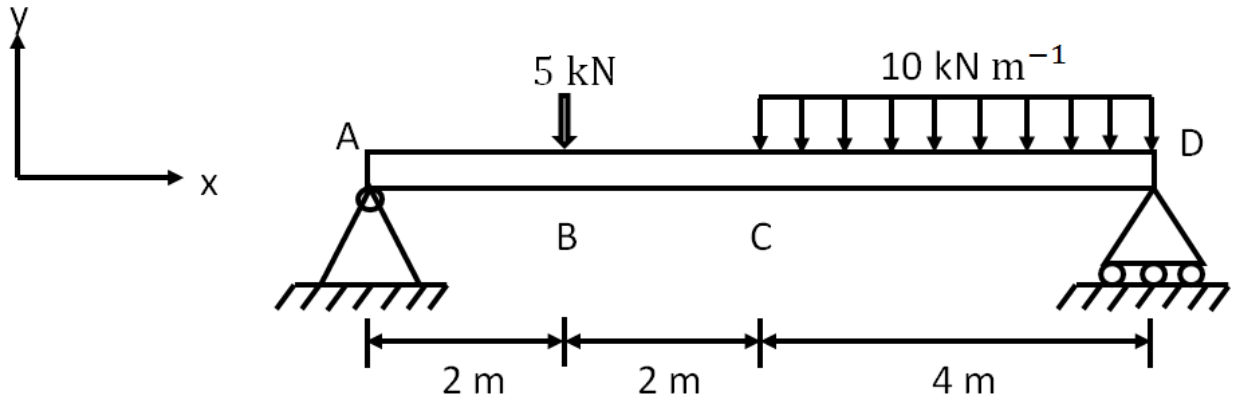

Fig. Q 3 (c)

QUESTION FOUR (20 MARKS)

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

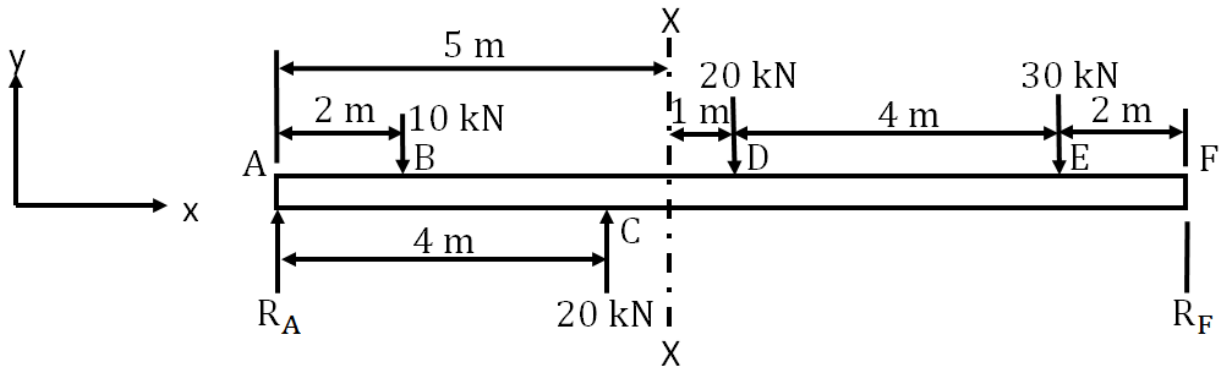

Fig. Q 4 (b)

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]

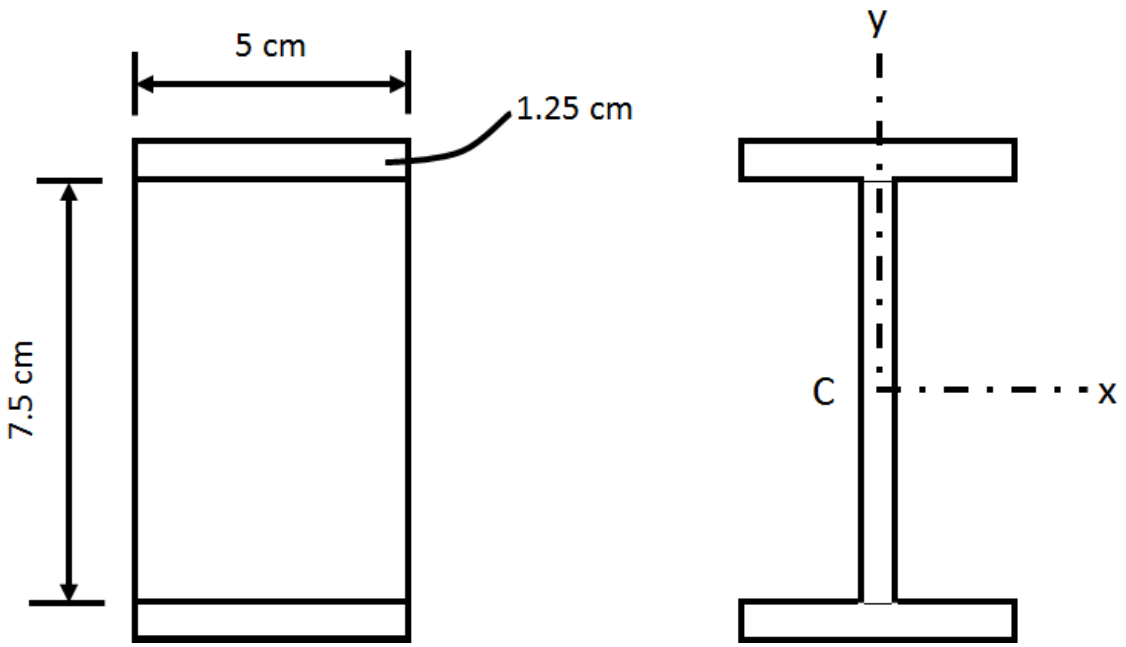

Fig. Q 4 (c)

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]

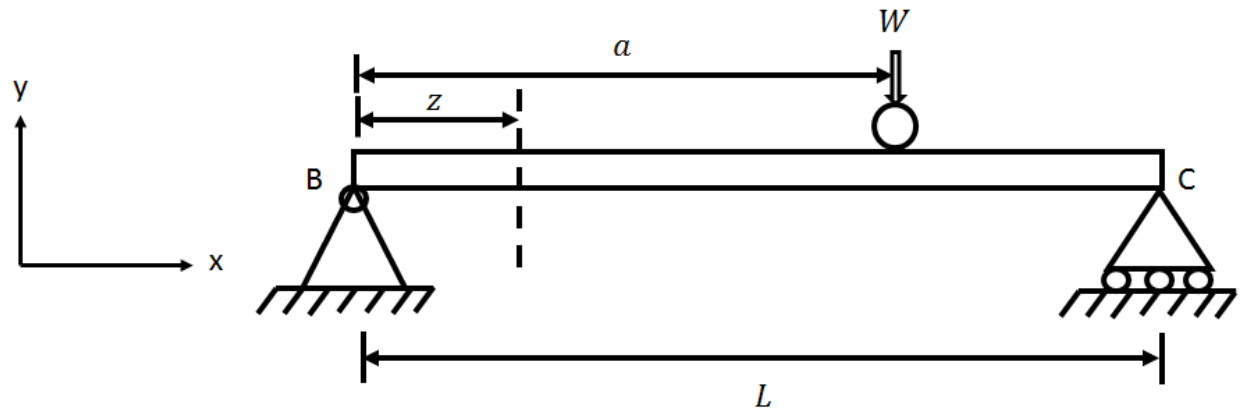

Fig. Q 5 (b)