MACHAKOS UNIVERSITY

University Examinations 2016/2017

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: 13/6/2017 **TIME: 11:00 – 1:00 PM**

INSTRUCTIONS

i *This paper consists of* ***FIVE*** *questions.*

ii *Answer* ***QUESTION ONE*** *and any other* ***TWO*** *questions.*

iii *Use* ***CLEAR, NEAT*** *and* ***WELL-LABELLED*** *sketches.*

iv *Marks will* be awarded for reasonably drawn and labeled diagrams.

Take

1) Modulus of elasticity of steel, E_{steel} = 200 GN/m^2.
2) Modulus of elasticity of wood, E_{wood} = 8.5 GN/m^2.

QUESTION ONE (COMPULSORY) (30 MARKS)

a) A flat steel bar shown on figure Q1(a) below is 25 mm wide by 6 mm thick and 1 m long. The bar is bent by couples applied at the ends so that the midpoint deflection is 25 mm. Compute the stress in the bar and the magnitude of the couples. Take E = 200 GN/m^2.

(8 marks)

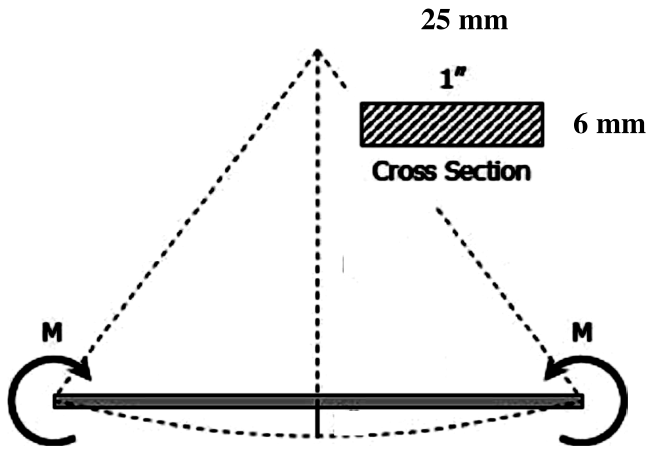

Figure Q1(a)

b) Figure Q1(b) shows a rigid bar ABC that forms part of a frame. The bar is pinned at B and attached to the two vertical rods; a steel rod at point *A* and an aluminum rod at point *C*. The data of the aluminum and steel bars are as shown on Table Q1(b).

<u>Table Q</u>

	Steel	Aluminum
Length, L in meters	0.9	1.2
Area, A in mm^2	300	1200
Young's modulus of elasticity in Giga-Pascals	200	70
Coefficient of thermal expansion in μm/(m.°C)	11.7	23
Distance to pin B in meters	0.6	1.2

Initially, the bar is horizontal and the vertical rods are stress-free. Determine the stress in the aluminum rod if the temperature of the steel rod is decreased by 40°C. Neglect the weight of bar ABC. (10 marks)

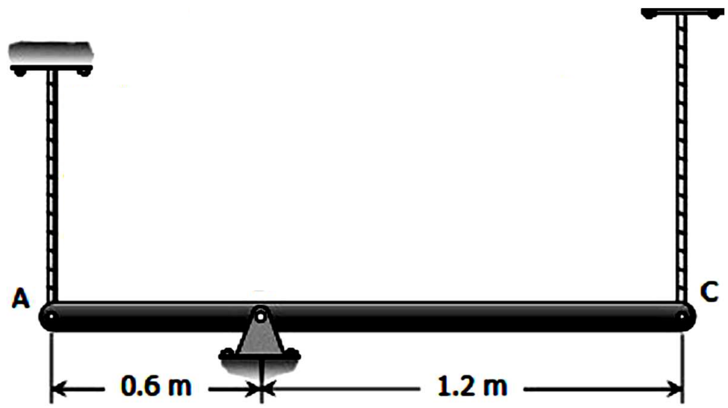

Figure Q1(b)

c) Consider a helical spring made of circular wire and subjected to an axial load W, as shown in figure Q1(c) below.

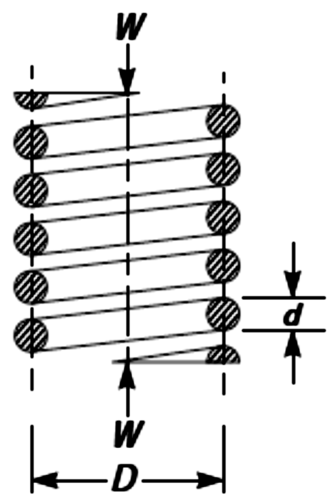

Figure Q1(c)

Letting D = Mean diameter of the spring; d = diameter of the spring; n = number of active coils; G = modulus of rigidity of spring material; W = axial load on the spring; τ = maximum shear stress induced in the wire; C = spring index = D/d; p = pitch of coils; δ = deflection of the spring as a result of axial load, W and K_s = shear stress factor;

i Derive the spring rate, W/ δ in terms of G, d, C and n. (4 marks)

ii A helical spring is made from a wire 6 mm diameter and has an outside diameter of 75 mm. if the permissible shear stress is 350 MPa and modulus of rigidity 84 KN/mm^2, find the axial load, W , which the spring can carry and the deflection per active turn. (8 marks)

QUESTION TWO (20 MARKS)

a) Figure Q2 show a beam of length 9a and simply supported at the ends. The beam supports a distributed load varying in magnitude linearly from zero at the left hand end to 3.6 wN/m at a distance 6a meters from the left hand support and another uniformly distributed load of magnitude wN/m over the remaining 3a meters. A clockwise couple of magnitude $8wa^2$ N-m is applied at a point 6a meters from the left hand support. Calculate the reactions at the supports and draw to scale the shear force and bending moment diagrams. (20 marks)

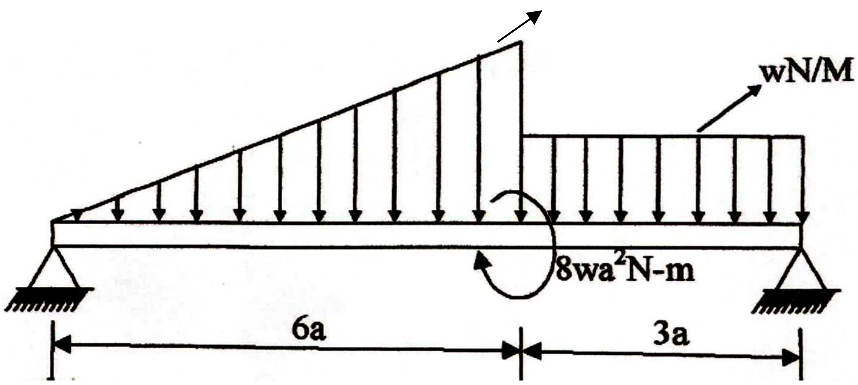

Figure Q2

QUESTION THREE (20 MARKS)

Figure Q3 shows a beam of length 9a meters supported at the ends. The beam supports a distributed load varying in magnitude from zero at the left end to wN/m at the right hand end. The beam also supports a point load of magnitude 6wa N as well as an anticlockwise couple of $6wa^2$ N-m at a point 3a meters from the left hand end. The cross section of the beam is indicated in figure Q3 (ii) with all dimensions indicated as a function of 'a'.

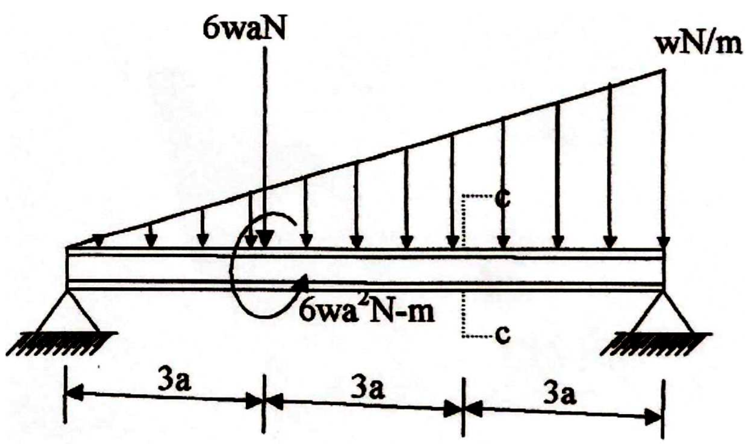

Figure Q3

Derive expressions for the maximum tensile stress and maximum compressive stress at a section C-C located at a section 3a meters from the right hand support. (20 marks)

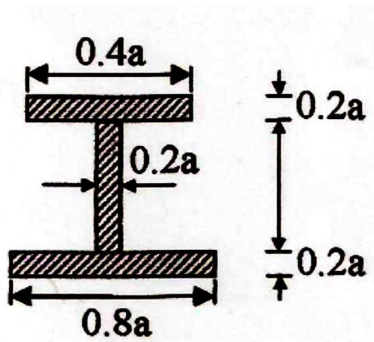

Figure Q3(ii)

QUESTION FOUR (20 MARKS)

a) Figure Q4 shows a cantilever beam of length 6a meters and fixed at the left hand end. The beam supports a distributed load varying in magnitude from zero at the left hand end to wN/m at the center of the beam, a point of magnitude $6wa^2$ N-m at the free end and two clockwise moments each of magnitude $6wa^2$ N-m at the center and at the free end.

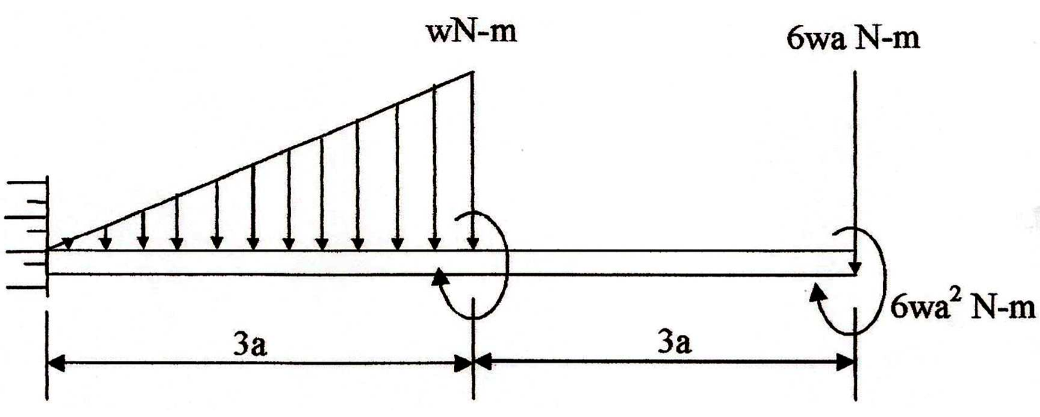

Figure Q4

Derive in terms of the indicated parameters, expressions for the slope and the deflection of the beam at the center of the beam taking *E* as the modulus of elasticity of the beam material and *I* as second moment of area of the cross section. (20 marks)

QUESTION FIVE (20 MARKS)

Figure Q5 shows a wooden beam 400 mm x 200 mm reinforced by rigidly attaching two steel plates of dimensions 400 mm x 20 mm to the left hand side and another of dimensions 200 mm x 20 mm on the left hand side.

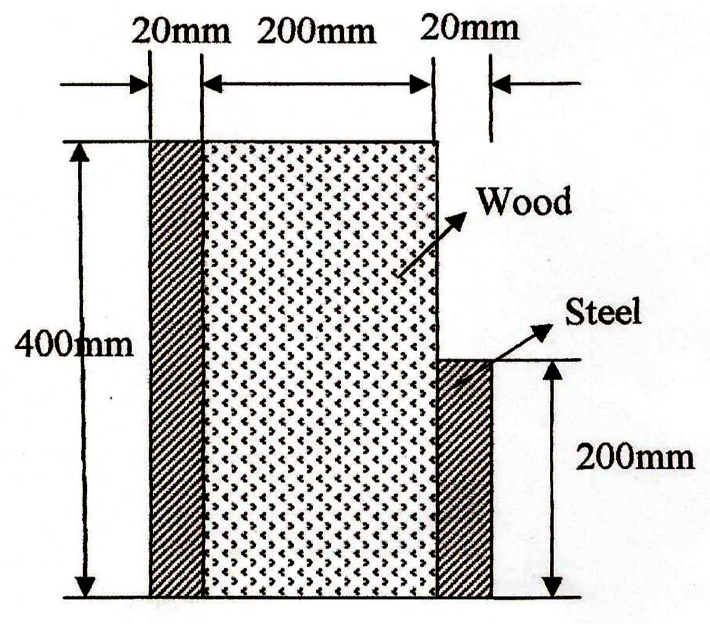

Figure Q5

If the maximum allowable stress is 135 MN/m^2 and that in load is 8MN/m^2. Calculate the maximum allowable bending moment that the beam can withstand (20 marks)