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 302: SOLID AND STRUCTURAL MECHANICS 1

DATE: 23/3/2021 **TIME: 2.00-4.00 PM**

INSTRUCTIONS

- *This paper contains FIVE questions*
- *Question ONE is compulsory and carries 30 Marks while the rest (Questions TWO – FIVE) carries 20 Marks each*

QUESTIONS ONE (30 MARKS)

a) State Hooke's Law. (2 marks)

b) i) What is the difference between engineering stress and true stress in a tensile test? (2 marks)

ii) State the equation that relates the true strain and the engineering strain (1 mark)

c) How does the change in cross-sectional area of a test specimen in a compression test differ from its counterpart in a tensile test specimen? (2 marks)

d) A tensile test uses a test specimen that has a gage length of 52 mm and an area = 205 mm^2. During the test the specimen yields under a load of 99,000 N. The corresponding gage length = 50.23 mm.This is the 0.2 percent yield point. The maximum load = 168,000 N is reached at a gage length =64.2 mm. Determine:

i. yield strength Y, (1 mark)

ii. modulus of elasticity E, and (1 mark)

iii. tensile strength TS. (1 mark)

e) A rectangular steel block is loaded as shown in **Fig. Q 1e**

i. Determine the strain in the direction of each force (3 marks)

ii. Calculate the change in volume (3 marks)

iii. Determine the bulk modulus K and Modulus of rigidity G.

(Assume Poisson's ratio = 0.25 and Elastic Modulus = 210 GPa) (4 marks)

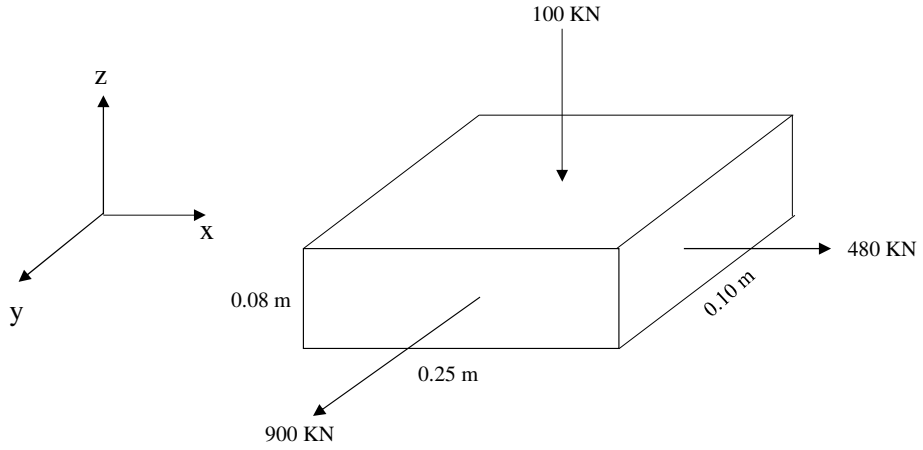

Fig. Q 1e

f) Differentiate between the elastic range and plastic range in the stress-strain curve of a material (2 marks)

g) Using a diagram describe and illustrate how to determine the yield strength from the stress-strain curve for a material without a definite yield point (3 marks)

h) List at least four theories of failure. (2 marks)

i) Define Poisson's ratio (1 mark)

j) State at least two assumptions made in the derivation of the torsion equation (2 marks)

QUESTION TWO (20 MARKS)

a) An element in plane stress is subjected to stresses $\sigma_x = 100\ Mpa$, $\sigma_y = 34\ Mpa$ and $\tau_{xy} = 28\ Mpa$. Using Mohr's circles, determine (a) the stresses acting on an element rotated through an angle $\theta = 40°$ (b) the principal stresses, and (c) the maximum shear stresses. Show all results on sketches of properly oriented elements. (12 marks)

b) A Mild Steel shaft, 120 mm diameter is subjected to a maximum torque of 20 KN and a maximum bending moment of 12 KNm at a particular section. Determine the factor of safety according to Tresca's yield criterion if the yield stress of the material in simple tension is 220 MPa. (8 marks)

QUESTION THREE (20 MARKS)

a) Derive equations for hoop and longitudinal stresses in a thin pressure vessel. (6 marks)

b) A thin cylindrical pressure vessel of 1.2 m diameter generates steam at a pressure of 1.75 N/mm2. Find the minimum wall thickness, if

i. the longitudinal stress does not exceed 28 MPa; and (2 marks)

ii. the circumferential (hoop) stress does not exceed 42 MPa. (2 marks)

c) Describe the following terms used in connection with compression springs

(1) Solid Length and (2) Free length (2 marks)

d) A closely coiled helical spring is made of 10 mm diameter steel wire, the coil consisting of 10 complete turns with a mean diameter of 120 mm. The spring carries an axial pull of 200 N. Determine the shear stress induced in the spring neglecting the effect of stress concentration. Determine also the deflection in the spring, itsstiffness and strain energy stored by it if the modulus of rigidity of the material is 80 kN/mm^2. (8 marks)

QUESTIONS FOUR (20 MARKS)

a) A composite bar made of aluminium and steel is held between the supports as shown in Figure Q4a. The bars are stress free at a temperature of 37°C. What will be the stress in the two bars when the temperature is 20°C, if (i) the supports are unyielding; and (ii) the supports yield and come nearer to each other by 0.10 mm. It can be assumed that the change of temperature is uniform all along the length of the bar. (10 marks)

$$Take\ E_s = 210\ GPa;\ E_a = 74\ GPa;\ \alpha_s = 11.7 \times 10{-}6\ /\ °C;\ and\ \alpha_a = 23.4 \times 10{-}6\ /\ °C.$$

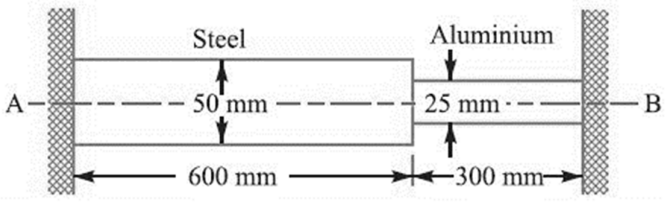

Figure Q4a

b) A shaft is transmitting 97.5 kW at 180 rpm. If the allowable shear stress in the material is 60 MPa, find the suitable diameter for the shaft. The shaft is not to twist more than 1° in a length of 3 metres. Take the Modulus of rigidity of the shaft material to be 80 GPa. (6 marks)

c) A steel shaft 35mm in diameter and 1.2m long held rigidly at one end has a hand wheel 500mm in diameter keyed to the other end. The modulus of rigidity of steel is 80GPa.

i) What load applied to tangent to the rim of the wheel produces a torsional shear of 60MPa? (2 marks)

ii) How many degrees will the wheel turn when this load is applied? (2 marks)

QUESTIONS FIVE (20 MARKS)

a) Figure Q5a shows a pin-jointed frame carrying a vertical load at B and a horizontal load at D. Find the forces in the members DF, HE and DH of the frame. (8 marks)

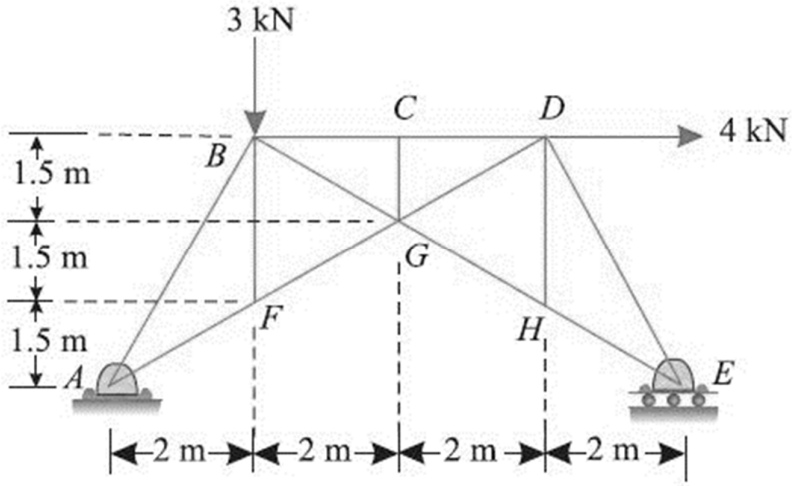

Figure Q5a

b) A hollow shaft of 40 mm outer diameter and 25 mm inner diameter is subjected to a twisting moment of 120 N-m, simultaneously, it is subjected to an axial thrust of 10 KN and a bending moment of 80 N-m. Calculate the maximum compressive and shear stresses. (8 marks)

c) Briefly describe how a tensile test is carried out (4 marks)