MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 302: SOLID AND STRUCTURAL MECHANICS 1

DATE: 22/7/2019 **TIME: 2.00-4.00 PM**

INSTRUCTIONS:

Answer Question One and Any Other Two Questions

QUESTION ONE (30 MARKS)

a) The following data were recorded during the tensile test of a 14-mm-diameter mild steel rod. The gage length was 50 mm.

Load (N)	Elongation (mm)	Load (N)	Elongation (mm)
0	0	46 200	1.25
6 310	0.010	52 400	2.50
12 600	0.020	58 500	4.50
18 800	0.030	68 000	7.50
25 100	0.040	59 000	12.5
31 300	0.050	67 800	15.5
37 900	0.060	65 000	20.0
40 100	0.163	65 500	Fracture
41 600	0.433		

Plot the stress-strain diagram and determine the following mechanical properties: (a) modulus of elasticity; (c) yield point; (d) ultimate strength; and (e) rupture strength. (12 marks)

b) Define the following types of stresses:

i. Compressive stresses (2 marks)

ii. Shear stresses (2 marks)

c) A hollow steel tube with an inside diameter of 100 mm must carry a tensile load of 400 kN. Determine the outside diameter of the tube if the stress is limited to 120 MN/m^2. (4 marks)

d) Differentiate between Von Mises and Tresca's yield theories (4 marks)

e) Define "Torsion" and state the torsion equation defining all the variables in the equation (4 marks)

f) Define bulk modulus and shear modulus (2 marks)

QUESTIONS TWO (20 MARKS)

a) The structure in Figure Q2(a) is a truss which is pinned to the floor at point A, and supported by a roller at point D. Determine the force to all members of the truss.

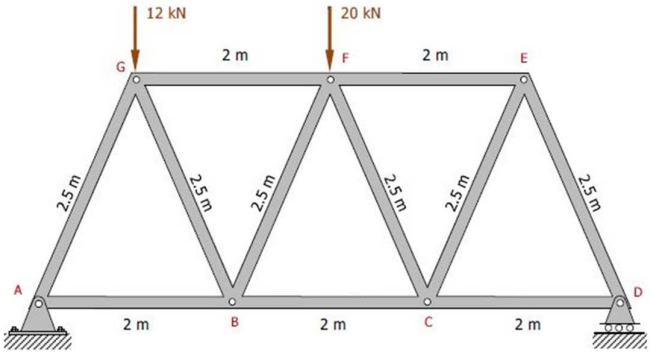

Figure Q2(a)

b) A hollow bronze shaft of 75 mm outer diameter and 50mm inner diameter is slipped over a solid steel shaft 50mm diameter and of the same length as the hollow shaft as shown in figure Q2(b). The two shafts are then fastened rigidly together at their ends. For bronze, G = 41 GPa, and for steel, G = 80 GPa. What torque can be applied to the composite shaft without exceeding a shearing stress of 55 MPa in the bronze or 83 MPa in the steel? (10 marks)

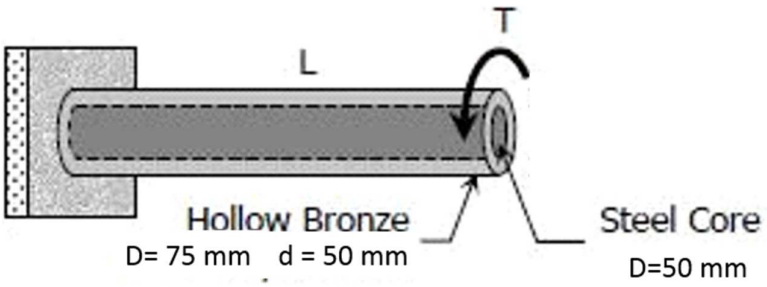

Figure Q2(b)

QUESTIONS THREE (20 MARKS)

a) i Differentiate between thick and thin shell pressure vessels (2 marks)

ii A cylindrical pressure vessel is fabricated from steel plating that has a thickness of 20 mm. The diameter of the pressure vessel is 450 mm and its length is 2.0 m. determine the maximum internal pressure that can be applied if the longitudinal stress is limited to 140 MPa, and the circumferential stress is limited to 60 MPa. (6 marks)

b) 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/mm2, find the axial load, W , which the spring can carry and the deflection per active turn. (8 marks)

QUESTIONS FOUR (20 MARKS)

a) Steel railroad reels 10 m long are laid with a clearance of 3 mm at a temperature of 15°C. At what temperature will the rails just touch? What stress would be induced in the rails at that temperature if there were no initial clearance? Assume α = 11.7 μm/(m·°C) and E = 200 GPa. (8 marks)

b) A rectangular steel block is loaded as shown in Figure Q4(b)

i. Determine the strain in the direction of each force

ii. Calculate the change in volume

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

(Assume Poisson's ratio = 0.25 and Elastic Modulus = 200 GPa)

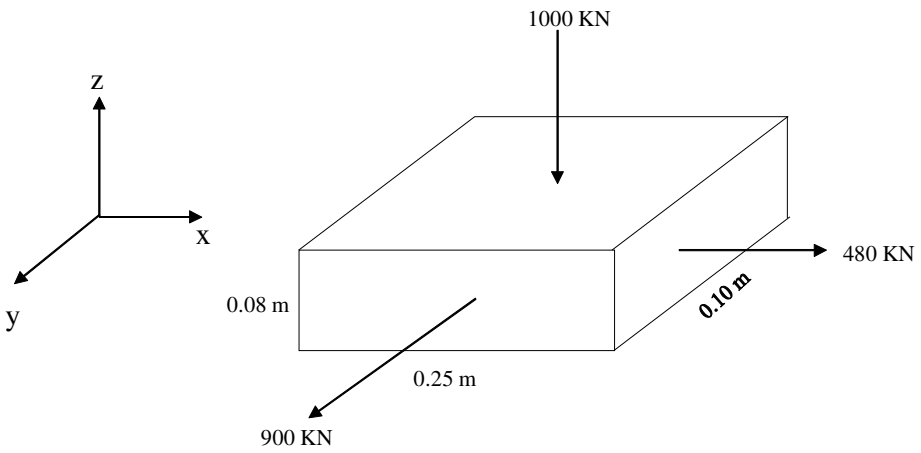

Figure Q4(b)

(12 marks)

QUESTIONS FIVE (20 MARKS)

a) An element in plane stress is subjected to stresses $\sigma_x = 84\ Mpa$, $\sigma_y = -30\ Mpa$ and $\tau_{xy} = -32\ Mpa$. Determine

i. The stresses acting on an element rotated through an angle $\theta = 40°$

ii. The principal stresses, and

iii. The maximum shear stresses. Show all results on sketches of properly oriented elements. (15 marks)

b) A short hollow circular cast iron cylinder is to support an axial compressive load P = 580 kN. The ultimate tensile strength (UTS) of cast iron on compression is 270 Mpa. It is decided to design the cylinder with a wall thickness t = 25mm and a factor of safety. Calculate the minimum required outside diameter (5 marks)