TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF BUILDING & CIVIL ENGINEERING
UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

ECV 4211 : STRENGTH OF MATERIALS I

SPECIAL/SUPPLEMENTARY EXAMINATION
SERIES: JULY 2025

TIME: 2 HOURS

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of five questions.

Attempt question ONE (Compulsory) and any other TWO questions.

Do not write on the question paper.

QUESTION 1 (COMPULSORY) 30 marks

a) Figure 1(a) and figure 1(b) illustrates elevation of a beam and a cross section respectively. Using the principle of bending stresses in beams, determine the maximum tensile and compressive stresses.

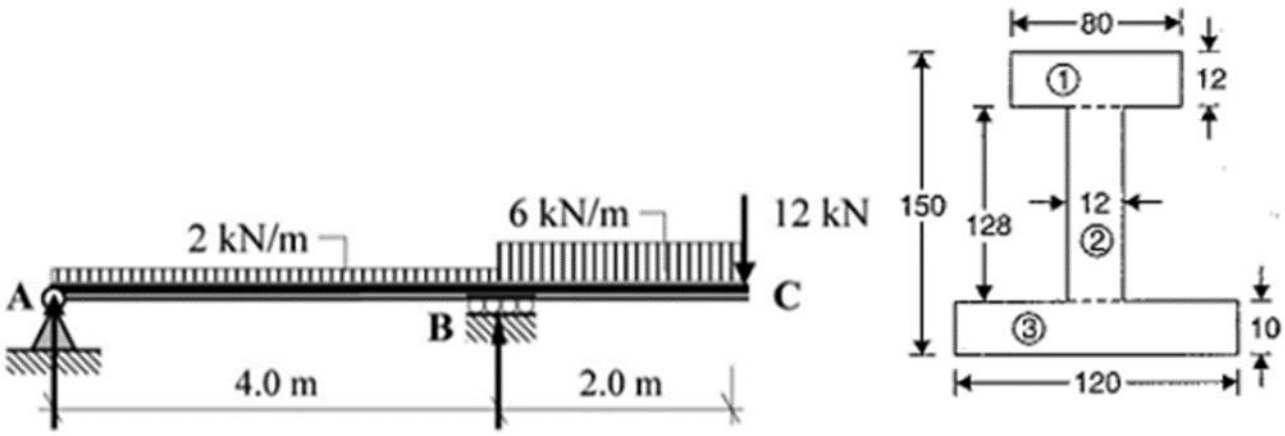

Figure 1(a) and (b)

(12 marks)

b) A weight of 25 tonnes is supported by a short square concrete column of 25cmx25cm in section and strengthened by four steel bars in the four corners of the section. The diameter of each bar 3cm. Find the stress in the steel and in concrete. Take $E_s=15E_c=2100$ tonnes/cm^2.

If the stress in concrete must not exceed 20Kg/cm2, what area of steel is required in order that the column may support a 40tonnes load.

(6 marks)

c) A bar of rectangular section 20mmx30 mm caries an axial force of 10 Kn. Determine the normal and shear force on plane inclined at 300 to the axis of the bar as shown on figure1 (d) below. Also determine the magnitude and nature of the normal and shear stresses on the inclined plane.

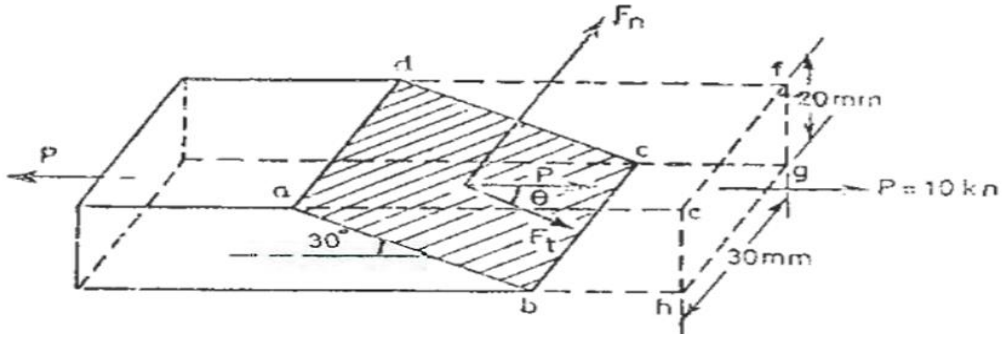

Figure 2(c)

(6marks)

d) A semi-circle area is removed from a trapezoid as shown in figure 1(c). Determine the centroid of the remaining area.

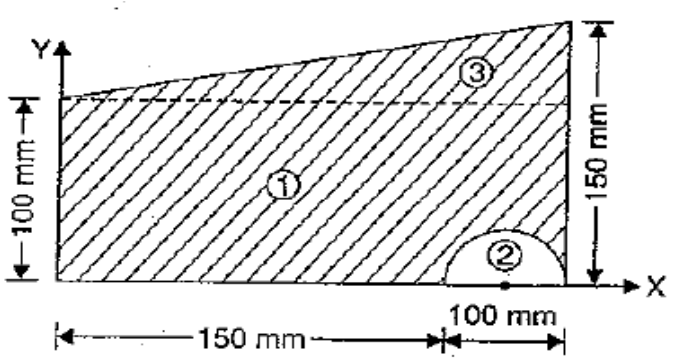

Figure 1(d)

(6 marks)

QUESTION 2

a) A stepped circular bar having diameters 20mm, 15 mm and 10mm over axial length of 100 mm, 80 mm and 60 mm is subjected to axial tensile force of 5 Kn. If $E=100x10^3$ N/mm^3 and I/m =0.32 for the material of the bar, determine

i) Total change in length

ii) Change in each diameter.

(6 marks)

b) Figure. 2(a) shows a two tie rods jointed through a pin of diameter d. The tie rods system transmits a tension force of 10 Kn. Determine the diameter of the pin, if the shear stress in the pin is not to exceed 100N/mm2.

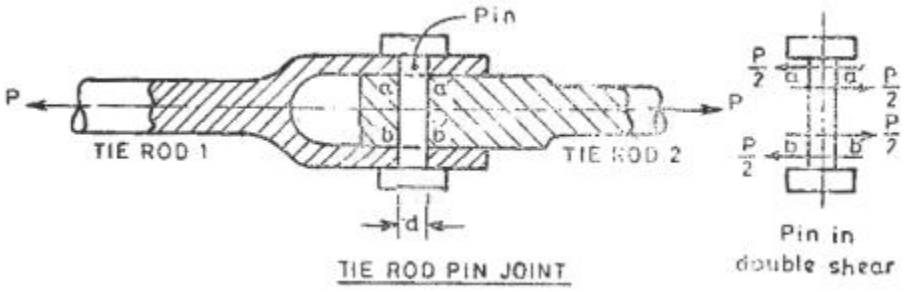

Figure 2(a)

(3marks)

c) An Aluminum alloy specimen 12.5 mm diameter and 5 mm cm gauge length was tested under tension. During the first part of the test, following readings were recorded.

Load (Kg)	0	750	1000	1250	1500	1750	2000
Extension (mm)	0	0.327	0.450	0.568	0.756	0.120	0.216

On a graph paper, plot the load extension diagram and determine the following values.

i) Young modulus of elasticity

ii) Limit of proportionality

iii) 0.1% proof stress.

(11 marks)

QUESTION 3

a) List the six assumptions made in the theory of simple bending and CLEARLY explain the theory of simple bending and derive an expression for bending stress. Use well illustrated sketches.

(10 marks)

b) A circular steel bar of 10 mm diameter gauge length is tested under tension. A tensile force of 10 Kn increases its length by 0.06 mm while the diameter is decreased by 0.0018 mm. Determine ;

i) Young's modulus of elasticity.

ii) Poisson's ratio for the material of the bar.

(6marks)

c) Derive the expression for second moment of area of a rectangle about the vertical axis passing though the centroid of the section, ie $I_{yy} = db^3/12$.
Solution.

(4 marks)

QUESTION 4

a) Define the following material properties in relation to structural mechanics.

i) Ductile Materials
ii) Brittle Material.
iii) Resilience proportional limit.
iv) Proof Stress

(4 marks)

b) A steel bar of 30 mm x 10 mm is placed between equal size bars of aluminium and brass. An axial compressive force of 60Kn is applied on the composite section. Determine the stresses experienced in each of the three bars. Take ,

Take E_{st} =210x10^3 N/mm^2, E_{All} =70x10^3 N/mm^2, E_{Brass} =105x10^3 N/mm^2

(4 marks)

c) Using integration, derive the flexure formula.

$$\frac{M}{I_{xx}} = \frac{E}{R} = \frac{f}{y}.$$ (flexure formula)

(12 marks)

QUESTION 5

a) A 25 mm diameter bar is subjected to an axial tensile load of 100kN. Under the action of this load a 200mm gauge length is found to extend 0.19 x 10^-3 mm. Determine the modulus of elasticity for the bar material. (4 marks)

b) If, in order to reduce weight whilst keeping the external diameter constant, the bar is bored axially to produce a cylinder of uniform thickness, what is the maximum diameter of bore possible given that the maximum allowable stress is 240MN/m2? The load can be assumed to remain constant at 100kN (5marks)

c) What will be the change in the outside diameter of the bar under the limiting stress quoted in (b)? (E = 210GN/m2 and v = 0.3). (5marks)

d) At a point on figure 5(a) which is strained. The planes BC and AC are perpendicular to each other. At plane BC the normal stress is 80 N/mm2 tensile, Shear stress is 15 N/mm2. On plane AC, the normal stress is 40 N/mm2 and shear stress is 15 N/mm2. The plane AB is 250 to the plane BC. Determine normal and shear stress on the plane AB. (6marks)

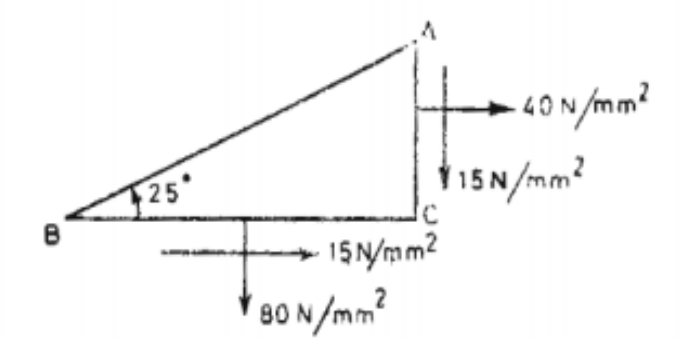

Figure 5(a)

(6marks)