MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

FIFTH YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 403: SOLIDS AND STRUCTURAL MECHANICS III

DATE: 9/3/2023 **TIME: 2:00-4:00 P.M**

INSTRUCTIONS

Answer question ONE and any other two questions.

All symbols have their usual meaning unless specified otherwise.

QUESTION ONE (30 MARKS)

a) **Fig Q1a** shows the cross-section of a beam that has yielded to a certain depth on application of a bending moment M. Determine the value of this bending moment, given that the yield stress is denoted as σ_y and the corresponding yielding moment is M_y (12 marks)

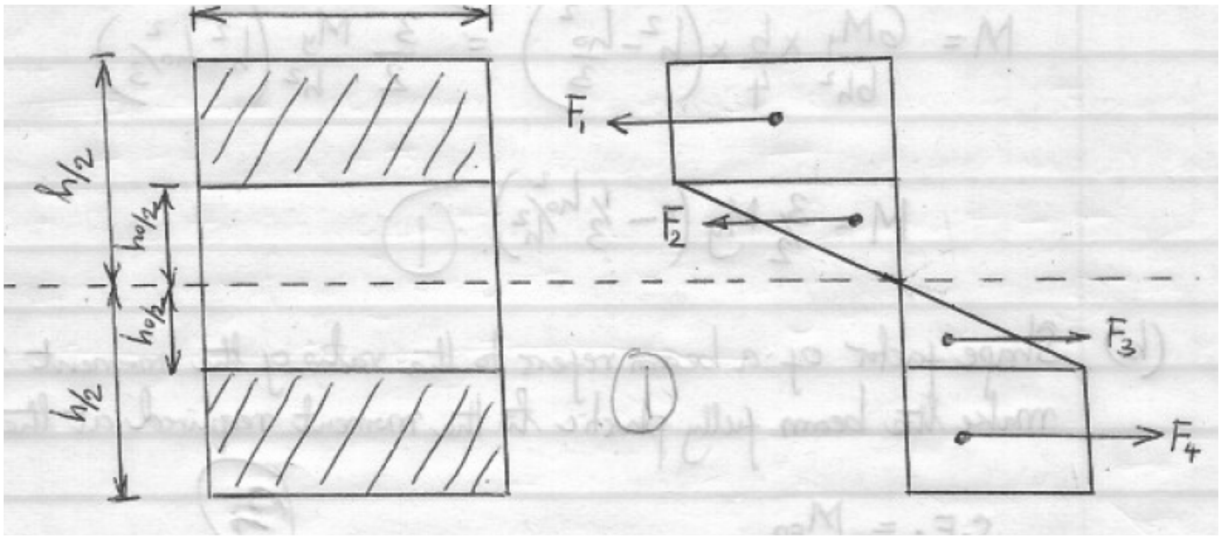
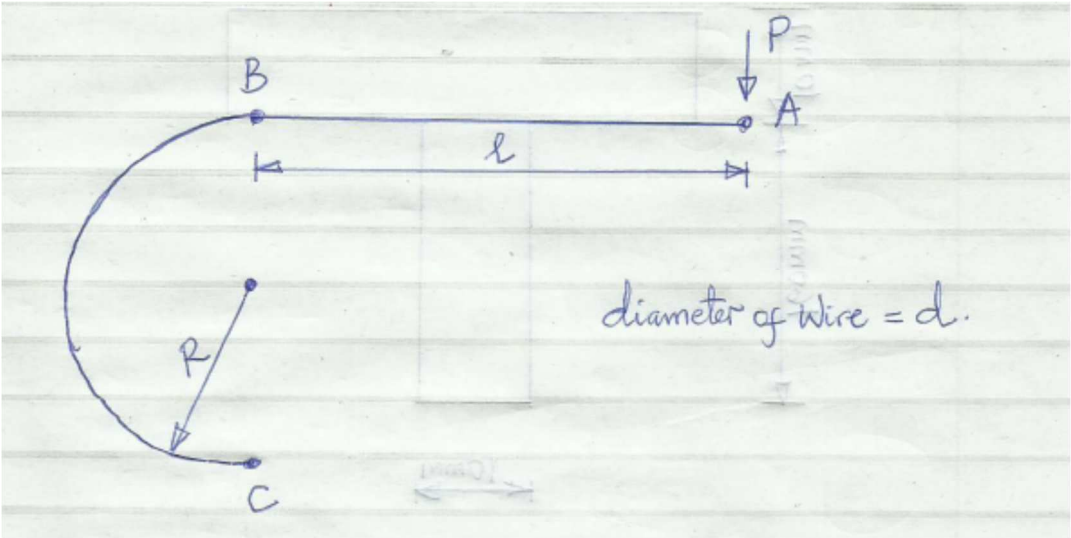


FIG Q1a

b) What do you understand by the term Shape Factor of a beam? Determine the shape factor of the beam in (a) above. (5 marks)

c) In **Fig Q1c**, show that the vertical deflection of point A is given by the following expression. (13 marks)

$$\partial = \frac{64P}{3\pi d^4 E}(3\pi R^3 + 12R^2L + 3\pi RL^2 + L^3)$$



FIQ Q1c

QUESTION TWO (20 MARKS)

a) A 45° strain rosette is struck to the surface of a steel shaft. Measurements of the changes in resistance of each gauge when the shaft was loaded gave strains of ε_{0°= +0.000592, ε_{45°= +0.000308 and ε_{90°= −0.000432. The angles are measured anti-clockwise from gauge A. (11 marks)

i. Determine the magnitude and directions of the principal strains.

ii. If the Young's modulus *E = 203 GPa* and Poisson's ratio *v = 0.33*, find the principal stresses at the point.

b) Using the Mohr's circle of strain, verify your answers obtained in part a (i) above: (9 marks)

QUESTION THREE (20 MARKS)

a) A channel section beam 1M long is built in at one end and subjected to a point load of 1 KN at the free end. If the direction of the load is as shown in **Fig Q3**, calculate the direction of the neutral axis, and the maximum values of the tensile and compressive stresses on the section. (16 marks)

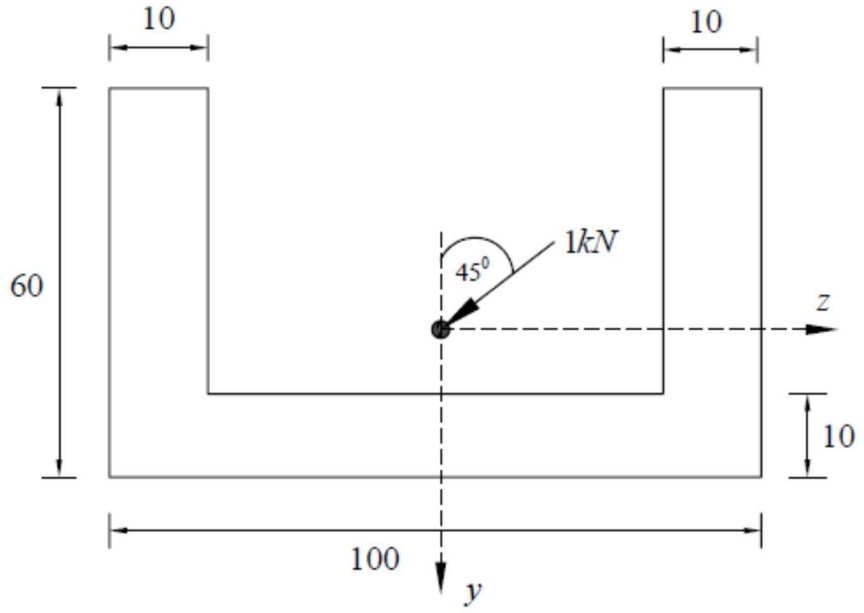


FIG Q3

b) A thin metal cylinder 450 mm long, 230 mm outside diameter and 215 mm inside diameter is subjected to an internal pressure and at the same time, an axial torque of 40 KN-m. Find the greatest internal pressure that can be applied if the maximum shearing stress is not to exceed 90 MPa. (4 marks)

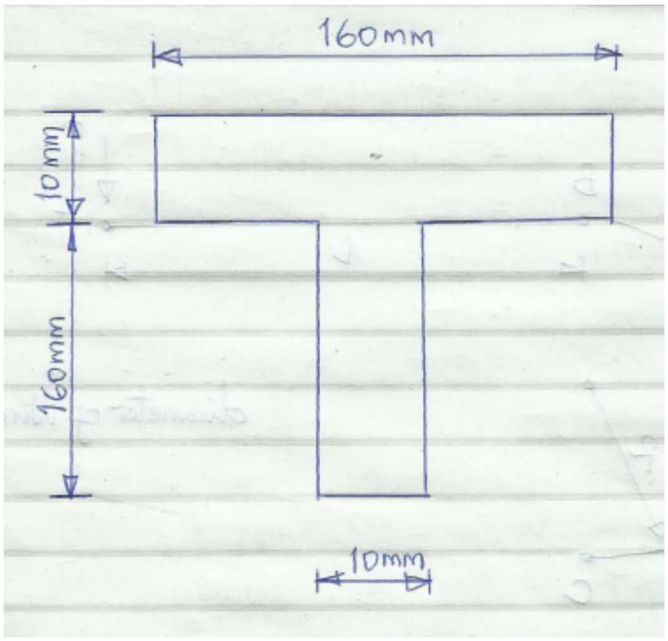
QUESTION FOUR (20 MARKS)

A beam has a T-cross section as shown in **Fig Q4**. The beam is subjected to a bending moment of such magnitude that yielding occurs over the lower 40 mm of the web although the yield stress is not developed at the top surface of the flange. The yield stress of the material is 250 MPa. Under these conditions, determine:

a) The location of the Neutral Axis of the beam

b) The value of applied moment that causes yielding over the lower 40 mm of the web

c) The value of applied moment that would cause the section to yield completely



FIQ Q4

QUESTION FIVE (20 MARKS)

a) Given lame's equations as:

$$\sigma_r = A + \frac{B}{r^2}$$

$$\sigma_c = A - \frac{B}{r^2}$$

Derive the equations for Radial (σ_r) and Circumferential (σ_c) stresses of a thick cylinder under internal pressure (P_i), clearly showing that the bore is the highly stressed part of this cylinder. Further, derive the equation for Longitudinal stresses (σ_L) of the cylinder and determine the arrangement of principal stresses based on the results of the three derivations.

(14 marks)

b) If the cylinder in (a) above undergoes Auto-Frettage process that causes the wall of the cylinder to yield to a certain radius (R_y). Show that the pressure the cylinder can accommodate just before yielding commences at the bore is given by the equation:(6 marks)

$$P_e = \frac{\sigma_y}{2}\left(1 - \frac{{R_1}^2}{{R_2}^2}\right)$$

$$Where\ \sigma_y = Yield\ Stress, R_1 = Internal\ Radius, R_2 = External\ Radius$$