



**JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**SCHOOL OF ENGINEERING AND TECHNOLOGY**

**UNIVERSITY EXAMINATION FOR THE DEGREE IN SCIENCE IN RENEWABLE  
ENERGY TECHNOLOGY AND MANAGEMENT**

**2<sup>ND</sup> YEAR 1<sup>ST</sup> SEMESTER 2024/2025 ACADEMIC YEAR**

**CENTRE: MAIN CAMPUS**

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**COURSE CODE: TEB 1203**

**COURSE TITLE: SOLID MECHANICS**

**EXAM VENUE:**

**STREAM: BSc. REN ENGY TEC & MGT**

**DATE: 16/1/2025**

**EXAM SESSION: 9-11.00 AM**

**DURATION: 2 HOURS**

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**Instructions**

- 1. Attempt any FOUR (4) questions**
- 2. Candidates are advised not to write on question paper**
- 3. Candidates must hand in their answer booklets to the invigilator while in the examination room.**

1. (a) What is:

- (i) Thermomechanical loading?
- (ii) A Solid?
- (iii) A Tensor?
- (iv) Constitutive equation?
- (v) Particle in continuum mechanics?
- (vi) Linear strain tensor?

(12 Marks)

(b) In three dimensional cartesian coordinate system, how many elements does:

- (i) A zero-order tensor have?
- (ii) A first order tensor have?
- (iii) A second order tensor have?
- (iv) What names do we use to describe (i) to (ii) above

(6 Marks)

(c) Evaluate the principal stress values

(9 Marks)

$$\sigma_{ij} = \begin{bmatrix} 3 & -1 & 0 \\ -1 & 3 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Given that:

$$I_1 = \sigma_{ii} = \sigma_{11} + \sigma_{22} + \sigma_{33} = \text{trace}(\tilde{\sigma})$$

$$I_2 = \frac{1}{2} [\sigma_{ii} \sigma_{jj} - \sigma_{ij} \sigma_{ji}]$$

$$I_3 = |\sigma_{ij}| = \frac{1}{6} [\sigma_{ij} \sigma_{jj} \sigma_{kk} - 3\sigma_{ii} \sigma_{jk} \sigma_{kj} + 2\sigma_{ij} \sigma_{jk} \sigma_{ki}]$$

$$\sigma_{pi}^o = \sigma_{pi}^o - \frac{1}{3} \delta_{ij} \sigma_{kk}$$

2. (a) What is:

- (i) A homogeneous body?
- (ii) An viscoelastic body?
- (iii) An plastic body?
- (iv) An inelastic body?
- (v) A viscoplastic body?
- (vi) An elastoviscoelastic body?

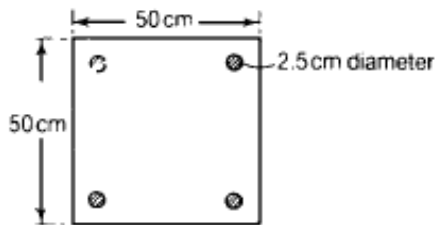
(12 Marks)

(b) A tensile test is carried out on a bar of mild steel of diameter 2 cm. The bar yields under a load of 80 kN. It reaches a maximum load of 150 kN, and breaks finally at a load of 70 kN. Estimate:

- i) the tensile stress at the yield point,
- ii) the ultimate tensile stress
- iii) the average stress at the breaking point, if the diameter of the fractured neck is 1 cm.

(4 Marks)

(c) A concrete column, 50 cm square, is reinforced with four steel rods, each 2.5 cm in diameter, embedded in the concrete near the corners of the square. If Young's modulus for steel is 200 GN/m<sup>2</sup> and that for concrete is 14 GN/m<sup>2</sup>, estimate the compressive stresses in the steel and concrete when the total thrust on the column is 1 MN.



(9 Marks)

3. (a) In solid mechanics, what is:

- (i) Constitutive Equation?
- (ii) Direct Stress?
- (iii) Shear Strain?
- (iv) Poisson's Ratio?
- (v) Working Stress?

(10 Marks)

(b) A pipe has an internal diameter of 12 cm and is 06 cm thick. What is the maximum allowable internal pressure if the maximum shearing stress does not exceed 65 MPa? Assume a uniform distribution of stress over the cross-section.

(7 Marks)

- (c) A long boiler tube has to withstand an internal test pressure of 6 MPa, when the mean circumferential stress must not exceed 130 MPa. The internal diameter of the tube is 6 cm and the density is 7900 kg/m<sup>3</sup>. Find the mass of the tube per meter run. (8 Marks)

4. (a) Define:

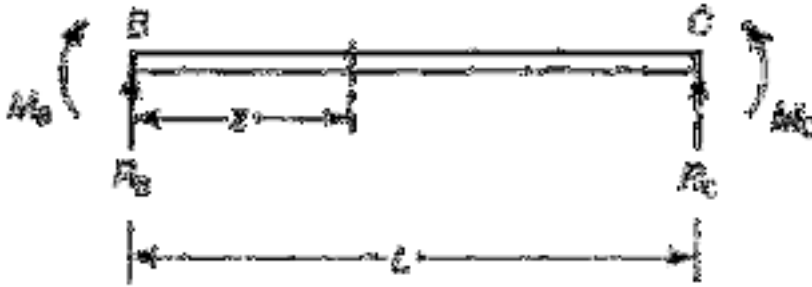
(i) Bending Moment Diagram?

(ii) Shear Force Diagram?

(iii) Strain Energy?

(9 Marks)

- (b) A beam rests knife-edges at each end, and carries a clockwise moment  $M$ , at B, and an anticlockwise moment  $M$ , at C. Construct bending moment and shear force diagrams for the beam.



(16 Marks)

5. (a) What is:

(i) Volumetric Strain?

(ii) Mohr's Circle of Stress?

(iii) Yield Criteria?

(9 Marks)

a) For the following state of stress

$$\sigma_{ij} = \begin{bmatrix} 10 & 5 & 0 \\ 5 & -20 & 0 \\ 0 & 0 & 0 \end{bmatrix} \times 10^7 \text{ pa}$$

If the yield stress from a one-dimensional tensile test is  $30 \times 10^7 \text{ N/m}^2$ , will there be yielding according to Rankine Criterion (Maximum Stress) and Tresca Criterion (Maximum Shear Stress Criterion)?

(16 Marks)