JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF ENGINEERING AND TECHNOLOGY

UNIVERSITY EXAMIMATION FOR THE DEGREE IN SCIENCE IN RENEWABLE ENERGY TECHNOLOGY AND MANAGEMENT

2ND YEAR 2ND SEMESTER 2023/2024 ACADEMIC YEAR

CENTRE: MAIN CAMPUS

COURSE CODE: TEB 1203

COURSE TITLE: SOLID MECHANICS

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

DATE: /04/2024 **EXAM SESSION:**

DURATION: 2 HOURS

Instructions

1. **Answer 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) Continuum Theory?

   (ii) A Solid?

   (iii) A Tensor?

   (iv) Constitutive equation?

   (v) Particle in continuum mechanics?

   (vi) Linear strain tensor?

   (12 Marks)

   (b) The stresses tensor at a point **p** is given with respect to axes x_i by the value of:

$$\sigma_{ij} = \begin{bmatrix} 3 & 1 & 1 \\ 1 & 0 & 2 \\ 1 & 2 & 0 \end{bmatrix}$$

   Determine the principal stress values (8 Marks)

   (c) Evaluate the principal stress deviator values (5 Marks)

$$\sigma_{ij} = \begin{bmatrix} -6 & -3 & 0 \\ -3 & 6 & 0 \\ 0 & 0 & 8 \end{bmatrix}$$

   Given that:

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

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

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

$$\sigma^o_{pi} = \sigma^o_{pi} - \frac{1}{3}\delta_{ij}\,\sigma_{kk}$$

2. (a) What is:

   (i) A inhomogeneous body?

   (ii) An anisotropic body?

   (iii) An orthotropic body?

(iv) An inelastic body?

(v) A viscoplastic body?

(vi) An elastoviscoelastic body? (12 Marks)

(b) The piston rod of a double-acting hydraulic cylinder is 20 cm diameter and 4 m long. The piston has a diameter of 40 cm, and is subjected to 10 MPa water pressure on one side and 3 MPa on the other. On the return stroke these pressures are interchanged. Estimate the maximum stress occurring in the piston-rod, and the change of length of the rod between two strokes, allowing for the area of piston-rod on one side of the piston. Take E = 200 GPa. (7 Marks)

(c) A uniform steel rope 250 m long hangs down a shaft. Find the elongation of the first 125 m at the top if the density of steel is 7840 kg/m3 and Young's modulus is 200 GPa. (6 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 10 cm and is 0.5 cm thick. What is the maximum allowable internal pressure if the maximum shearing stress does not exceed 55 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 4 MPa, when the mean circumferential stress must not exceed 120 MPa. The internal diameter of the tube is 5 cm and the density is 7840 kg/m3. Find the mass of the tube per meter run. (8 Marks)

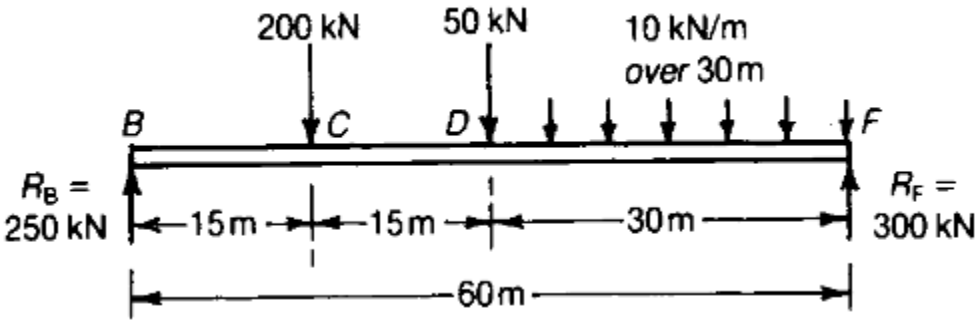
4. (a) Define:

(i) Bending Moment Diagram?

(ii) Shear Force Diagram?

(iii) Strain Energy? (9 Marks)

(b) A simply-supported beam carries concentrated lateral loads at C and Dand a uniformly distributed lateral load over the length DF. Construct the bending moment and shearing force diagrams.



(16 Marks)

5. (a) What is:

(i) Volumetric Strain?
(ii) Mohr's Circle of Stress?
(iii) Yield Criteria?

(9 Marks)

(b) What torque, applied to a hollow circular shaft of 25 cm outside diameter and 17.5 cm inside diameter will produce a maximum shearing stress of 75 MN/m2 in the material.

Given that:

$$J = \int_{a_1}^{a_2} 2\pi r^3 dr = \frac{\pi}{2}\left(a_2^4 - a_1^4\right)$$

(8 Marks)

(c) From tests on a magnesium alloy it is found that E is 45 GPa and G is 17 GPa. Estimate the value of Poisson's ratio.

Given that: $E=2(1+\upsilon)$ (8 Marks)

(d) A cylindrical block is 30 cm long and has a circular cross-section 10 cm in diameter. It carries a total compressive load of 70 kN, and under this load it contracts by 0.02 cm.

Estimate the average compressive stress over a normal cross-section and the compressive strain.