Register No.: .... Name: ....

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

THIRD SEMESTER B.TECH DEGREE EXAMINATION (S), FEBRUARY 2023
MECHANICAL ENGINEERING
(2020 SCHEME)

Course Code : **20MET201**

Course Name: **Mechanics of Solids**

Max. Marks : **100** **Duration: 3 Hours**

PART A

(Answer all questions. Each question carries 3 marks)

1. Define principal planes and principal stresses.
2. Given a displacement vector with components u_x, u_y and u_z, write down the strain-displacement relations for the six components of strain in the strain tensor.
3. Define Poisson's ratio. Write down the expressions for Shear Modulus (G) and Bulk Modulus (K) in terms of the Young's modulus (E) and Poisson's ratio.
4. Discuss the effects of thermal loading (and stresses developed) in bars of dissimilar materials in parallel which are rigidly connected at the ends.
5. List the assumptions in deriving the torsion equation.
6. Calculate the maximum shear stress at the centroid of a rectangular cross section 50mm wide and 100mm deep, subjected to a shear force of 100kN.
7. Obtain the tip deflection of a cantilever beam of length 'L' with a point load 'W' at the tip.
8. State Maxwell's reciprocal relation and explain its significance.
9. Discuss the effect of end conditions in the calculation of critical buckling load.
10. State the maximum shear stress theory of failure.

PART B

(Answer one full question from each module, each question carries 14 marks)

MODULE I

11. a) The stress tensor at a point is given by

$$\begin{bmatrix} 21 & 16 & 9 \\ 16 & 8 & 14 \\ 9 & 14 & 11 \end{bmatrix} \text{MPa}$$

Find stress invariants, characteristic equation, principal stresses and the principal plane associated with the maximum principal stress. (9)

b) If the displacement field is $(2x^2+y)\,\mathbf{i} + (3y^2+z)\,\mathbf{j} + (4z^2+x)\,\mathbf{k}$, obtain the strain tensor at (1,2,1). (5)

OR

12. a) The normal stresses on two mutually perpendicular planes are 100MPa and 20MPa (both tensile), and the shear stress is 40MPa. Using Mohr's circle, determine the principal stresses, principal planes, and the maximum shear stress. (10)

b) The stress tensor at a point is given by

$$\begin{bmatrix} 19 & 5 & 8 \\ 5 & 10 & 14 \\ 8 & 14 & 13 \end{bmatrix} \text{MPa}$$

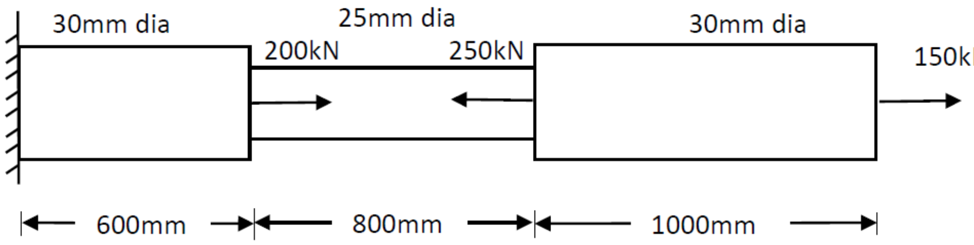
Find the resultant stress vector, and the normal and tangential components of stress on a plane with direction cosines given by (4)

$$\left\{\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}\right\}$$

MODULE II

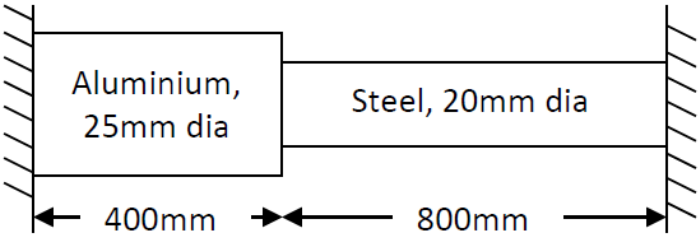
13. a) A steel bar of 10mm diameter is subjected to an axial load of 12kN. If the change in diameter is found to be 0.0022mm, determine the Poisson's ratio and the modulus of elasticity. Take G=78GPa. (7)

b) Find the total elongation of the composite bar shown below. The bar segment diameters are of 30mm, 25mm and 30mm respectively, and the bar lengths are 600mm, 800mm and 1000mm respectively. Take E=200GPa. (7)



OR

14. a) A composite bar made of aluminum and steel is rigidly attached to the end supports at 60°C as shown in figure. Evaluate the stresses in the two portions of the bar when the temperature of the system falls to 20°C. The modulus of elasticity of steel and aluminum are 200GPa and 70GPa respectively. The coefficient of thermal expansion of steel and aluminum: $11.7\times10^{-6}/^{\circ}C$ and $23.4\times10^{-6}/^{\circ}C$ respectively. (9)



b) Draw a typical stress-strain curve for mild steel subjected to tensile load and explain the salient points. (5)

MODULE III

15. a) An 8m long beam simply supported at the ends carries a point load of 20kN at 2m from the left end and a uniformly distributed load of 10kN/m on the right half of the span. Draw the shear force and bending moment diagrams indicating principal values. (9)

b) Find the maximum bending stress induced in a simply supported beam of length 4m, acted upon by a load of 100N at the mid-span. The beam has a rectangular cross-section 10mm wide and 20mm deep. (5)

OR

16. a) A solid shaft is proposed to be replaced by a hollow shaft (of the same length and the same material) for transmitting a power of 200kW at 100rpm. If the allowable shear stress of the material is 60MPa, find the percentage savings in weight if the inner diameter of the hollow shaft is 0.6 times the outer diameter. (8)

b) Derive the relation between shear force, bending moment and the intensity of loading. (6)

MODULE IV

17. a) Two point loads of 5kN and 15kN are acting on a 5m long simply supported beam at 1m and 2m respectively from the left end. Find the deflections under the applied loads. Also find the position and magnitude of the maximum deflection. Take E=200GPa, I=15 x 10^6 mm^4. (10)

b) State Castigliano's theorem. Express the equations for deflection and rotation at any point. (4)

OR

18. a) Determine the maximum deflection of a simply supported beam of span 'L' carrying a load of 'w' per unit length using any method. (8)

b) Derive strain energy expressions in terms of the geometry, material property, and load during i) Axial loading, (ii) Bending. (6)

MODULE V

19. a) Explain the maximum principal stress theory of failure and the maximum strain energy theory of failure. (6)

    b) Find the crippling load for a hollow steel column of external diameter 50mm and internal diameter 40mm. The column is 2.5m long and pinned at both ends. Use Rankine's formula with Rankine's constant as 1/7500 and crushing stress as 335MPa. (8)

OR

20. a) Derive the expression for Euler's buckling load for a column that is pinned at both ends. (6)

    b) The principal stresses at a point in an elastic material are 100MPa tensile, 25MPa tensile and 50MPa compressive. Determine the factor of safety against failure based on i) maximum principal stress theory, ii) maximum shear stress theory, and iii) maximum strain energy theory. The elastic limit in simple tension is 220MPa and Poisson's ratio is 0.3 (8)

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