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

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

FIFTH SEMESTER B.TECH DEGREE EXAMINATION (Regular), DECEMBER 2022
ROBOTICS AND AUTOMATION
(2020 SCHEME)

Course Code : **20RBT303**

Course Name: **Solid Mechanics**

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

PART A

(Answer all questions. Each question carries 3 marks)

1. Define state of stress at a point with the help of a neat figure.
2. Write down the six strain displacement relationships. Explain the terms:
3. For a given material, the Bulk modulus and the Young's modulus are same and equal to 150GPa. Find its shear modulus.
4. What are thermal stresses? Define co-efficient of thermal expansion.
5. State the assumptions made in deriving torsion equation.
6. Write the bending equation and explain the terms.
7. Differentiate strain energy and complimentary strain energy.
8. Write the governing differential equation of the beam.
9. Define the terms (i) buckling of columns and (ii) critical load.
10. Explain the significance of theories of failure.

PART B

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

MODULE I

11. a) The state of stress at a point is given by the following stress components: (7)

$\sigma_{xx} = 3$, $\sigma_{yy} =-2$,
$\sigma_{zz} = -1$, $\tau_{xy} = 0$,
$\tau_{yz} = 3$, $\tau_{xz} = 2$. (All units in MPa).

Determine the principal stresses.

b) For a given state of stress, $\sigma_{xx} = 40$, $\sigma_{yy} = 20$, $\sigma_{zz} = 10$, $\tau_{xy} = -10$, $\tau_{yz} = 30$, $\tau_{xz} = 20$ (All units in MPa), determine the normal stress and corresponding shear stress on a plane with $n_x = 0.5$ and $n_y = 0.1$. (7)

OR

12. a) The displacement field is given by (7)

$u_x = \left[(x^2+y^2)\, i + (y^2z+3x)\, j + (z^2+y)\, k\right] 10^{-4}$.

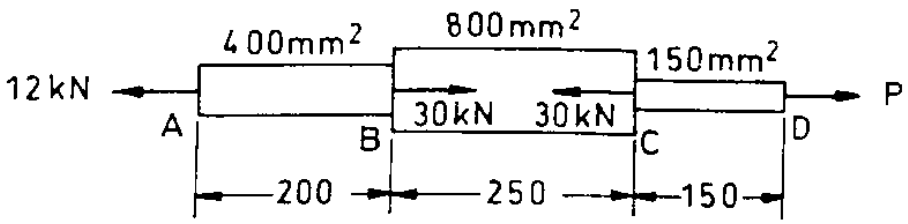
Form the strain matrix at the point (1,5,7).

b) Construct Mohr's circle to determine the principal stresses and the orientation of the principal stresses for the state of stress given by σ_{xx} = 100, σ_{yy} = 50, τ_{xy} = 40. (All units in MPa). Also determine the maximum shear stress. (7)

MODULE II

13. a) Explain the salient points in a stress-strain diagram of mild steel with the help of a neat figure. (6)

b) A stepped bar consists of three sections as shown below. The cross-sectional areas and the applied forces are indicated. Find the value of P for equilibrium, stresses in different zones and change of length of the bar. Take E = 200×10^3 N/mm^2. (8)

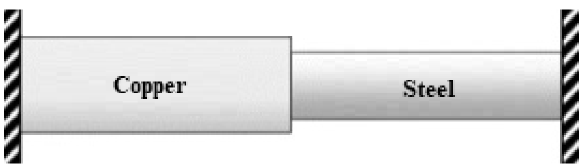


OR

14. a) In an experiment, a bar of 20 mm diameter is subjected to a pull of 50kN. The measured extension on a gauge length of 100 mm is 0.015 mm and the change in diameter is 0.04 mm. Calculate the Poisson's ratio and the value of modulus of rigidity. (6)

b) A composite bar made up of steel and copper have their diameters 25mm and 50mm and length 600mm and 300 mm respectively are held between two walls. The assembly is free of stress at 40^{0}C. Find what stresses will develop in the two materials if the temperature falls to 23^{0}C and the supports are perfectly rigid. (8)

Take E_s = 2×10^5 N/mm^2, E_c = 1.1×10^5 N/mm^2, α_s = $11.7 \times 10^{-6}/^0C$ and α_c = $17.5 \times 10^{-6}/^0C$.



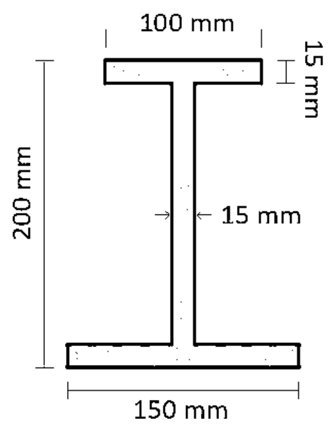
MODULE III

15. a) Compare the strength of a hollow shaft of diameter ratio 0.75 to that of a solid shaft by considering the permissible shear stress. Both the shafts are of same material, of same length and weight. (5)

b) Draw the Shear Force Diagram and Bending Moment Diagram for the simply supported beam of 6m span. A uniformly distributed load of 4 kN/m acts over a span of 2m from the left support and a point load of 10 kN is applied at a distance of 2m from the right support. Also determine the maximum bending moment and the location of the same. (9)

OR

16. A simply supported beam of span of 10 m carries a UDL of 50 kN/m. The cross section is of shape as given below. Calculate the maximum stress produced due to bending and plot the bending stress distribution. (14)



MODULE IV

17. a) A beam of length 10m is simply supported at its ends and carries two point loads of 50kN and 100kN at a distance of 1m and 5m respectively from the left support. Find: (9)
i. Deflection under each load,
ii. Maximum deflection, and
iii. The point at which maximum deflection occurs

b) Derive the expressions for elastic strain energy in terms of applied load and the material property for the cases of a) Axial force b) Torque. (5)

OR

18. a) State Castigliano's second theorem and explain its significance. (5)

b) A cantilever beam supports a UDL 5kN/m over its entire length and a concentrated load 4kN at the free end. Total span is 2m. Determine the deflection at the free end. Given EI = $5000 kNm^2$. (9)

MODULE V

19. a) Derive Euler's formula for a column with both ends pinned. (5)

b) Find the Euler's crushing load for a hollow cylindrical column made of cast iron 100mm external diameter and 20mm thick. The column is 5 m long, one end fixed and the other end hinged. E = 80GPa. Compare this load with the crushing load as given by Rankine's formula using constants σ_c = 550 N/mm^2 and α = 1/1600. (9)

OR

20. a) Explain: (i) Maximum Principal Stress Theory, (ii) Maximum Shear Stress Theory (5)

b) The stress induced at a critical point in a machine component (σ_{yield} = 360 N/mm^2) are σ_{xx} = 150 N/mm^2, σ_{yy} = 60 N/mm^2, τ_{xy} = 45 N/mm^2. Calculate the factor of safety based on (i) Maximum shear stress theory, (ii) Maximum normal stress theory (iii) Distortion energy theory. (9)

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