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

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

FIFTH SEMESTER B.TECH DEGREE EXAMINATION (R,S), DECEMBER 2023
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. Explain the significance of stress invariants.
2. Differentiate between plane stress and plane strain conditions.
3. State and explain generalized hooke's Law
4. Draw a true stress-strain curve for ductile material
5. State and explain the significance of section modulus
6. List the assumptions while deriving the torsional formula for a circular shaft.
7. State Maxwell's reciprocal relation
8. Write a short note on complementary strain energy.
9. What is slenderness ratio?
10. State Rankine's Theory for Maximum Normal Stress.

PART B

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

MODULE I

11. a) At a point in a given material, the three-dimensional state of stress is given by the following expressions. (12)

$\sigma_{xy}=\sigma_{yy}=\sigma_{zz}=10 N/mm^2$, $\tau_{xy}=20\ N/mm^2$, $\tau_{yz}=\tau_{xz}=10 N/mm^2$.

Find the stress invariants, principal stresses and principal plane.

b) Explain the equality of cross shear (2)

OR

12. a) At a point in a bracket, the normal stress on two mutually perpendicular planes are $120 N/mm^2$ tensile and $60 N/mm^2$ tensile. The shear stress across these planes is $30 N/mm^2$. Find using Mohr's circle, the principle stresses and maximum shear stress. (10)

b) The displacement field is given by (4)
$u=K(x^2+2z)$, $v=K(4x+ 2y^2+z)$, $w=4Kz^2$ where K is a constant.
Find the component of stress at (2,2,3) directions.

MODULE II

13. a) A steel bar is placed between two copper bars each having the same area and length as the steel bar at 15°C. At this stage, they are rigidly connected together at the ends. When the temperature is raised to 315°C, the length of the bars increases by 1.50mm. Determine the original length and final stresses in the bars. Take E_s= 2.1x10^{5}N/mm^2, E_c = 1x10^{5}N/mm^2, α_s=0.000012 per°C α_c=0.0000175 per°C (12)

b) What is Poisson's Ratio? (2)

OR

14. a) Write the stress-strain relationship for linear elastic isotropic materials in terms of Young's modulus and Poisson's ratio (5)

b) A bar of 40 mm diameter is subjected to a pull of 50kN. The measures extension on gauge length of 200mm is 0.1mm and the change in diameter is 0.004mm. Calculate (9)

i) Young's Modulus
ii) Poisson's Ratio
iii) Bulk Modulus

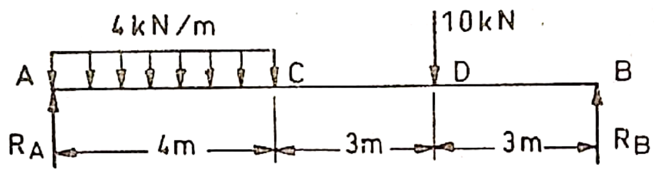
MODULE III

15. a) A solid shaft 125mm in diameter transmits 120kW at 160 rpm. Find the maximum shear stress induced in the shaft. Find also the angle of twist in the length of 7.5 m. Take G= 8x10^{4}N/mm^2 (7)

b) A solid shaft of 200 mm diameter has the same cross-sectional area as that of a hollow shaft of the same material with an inside diameter of 150mm. Find the ratio of power transmitted by the two shafts at the same speed. (7)

OR

16. a) Draw shear force and bending moment diagrams for the beam shown in figure and find the maximum bending moment and the location. (7)



b) 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. (7)

MODULE IV

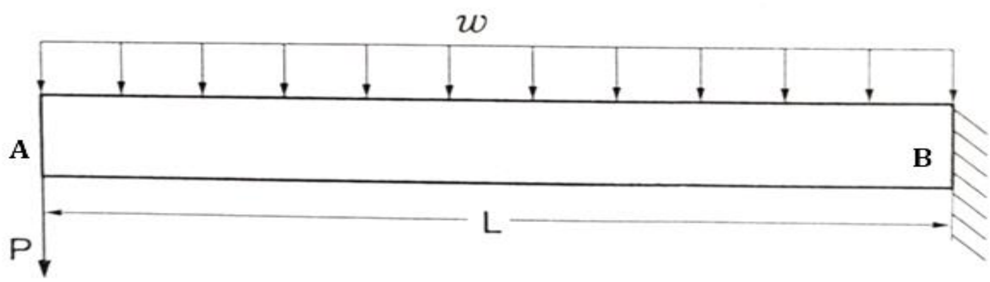
17. A beam of length 6m is simply supported at its ends and carries two point loads of 48 kN and 40 kN at a distance of 1m and 3m respectively from the left support. Find the following: (14)

   (i) deflection under each load.
   (ii) maximum deflection
   (iii) the point at which maximum deflection occurs.

   Take $E = 2 \times 10^5\ N/mm^2$ and $I = 85 \times 10^6\ mm^4$

OR

18. a) A cantilever beam AB supports a uniformly distributed load w and a concentrated load P as shown in fig. It is given that L= 2m, w=4kN/m, P=6kN and EI= 5MN.m^2. Determine deflection at point A. (7)



b) Derive an expression for strain energy due to (i) bending load and (ii) Axial loading (7)

MODULE V

19. a) A hollow alloy tube 5m long is having external and internal diameters equal to 40mm and 25mm respectively under a tensile load. Find the Euler's buckling load for the tube, when used as a column with both ends fixed. Also, find the safe compressive load for the tube with a factor of safety 4. (7)
Assume $E = 2 \times 10^5\ N/mm^2$ and $I = 15 \times 10^9\ mm^4$

b) A hollow cylindrical cast iron is 4 meters long, both ends being fixed. Design the column to carry an axial load of 250kN. Use Rankine's formula and adopt a factor of safety of 5. The internal diameter may be taken as 0.80 times the external diameter. Take σ_c= 550N/mm^2 and α= 1/1600 (7)

OR

20. a) Derive the equation to find a crippling load of columns when both ends are hinged by using Euler's 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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