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

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

FIFTH SEMESTER B.TECH DEGREE EXAMINATION (S), FEBRUARY 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. Discuss the stress at a point and express it as a matrix.
2. Write Cauchy's stress formula and its application.
3. Write generalized Hooke's law for linear elastic isotropic materials in terms of Young's Modulus and Poisson's Ratio in matrix form.
4. A steel bar clamped at two ends is experiencing a temperature fall of 50°C. Find the stress produced in the bar if its initial length was 1.5 m and supports yield by 0.2mm. Take $\alpha=12x10^{-6}/°C$, $E=2x10^5 N/mm^2$
5. Explain torsion equation and assumptions used in deriving torsion equation.
6. Write short notes on (i) Torsional Rigidity and (ii) Flexural Rigidity.
7. Compare Strain Energy and Complementary Strain Energy.
8. Discuss about Castigliano's Second Theorem
9. Define Critical Load and Slenderness Ratio.
10. What is the significance of Factor of Safety?

PART B

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

MODULE I

11. a) The rectangular stress components at a point are given by $\sigma_x=2kPa$, $\sigma_y=-4kPa$, $\sigma_z=4kPa$, $\tau_{xy}=2$ kPa, $\tau_{yz}=-4$ kPa, $\tau_{xz}=3kPa$. Find the principal stresses and check for invariance. (7)

    b) At a point in the structural member, the stresses (in MPa) are given by $\sigma_x=50$, $\sigma_y=30$, $\tau_{xy}=25$. Employ Mohr's circle to determine: (7)
    (i) The magnitude and orientation of the principal stresses.
    (ii) The magnitude and orientation of the maximum shear stress.

OR

12. a) State of stress at a point is given below. Determine the normal and shearing stresses on a plane that is equally inclined to all the coordinate planes. (7)

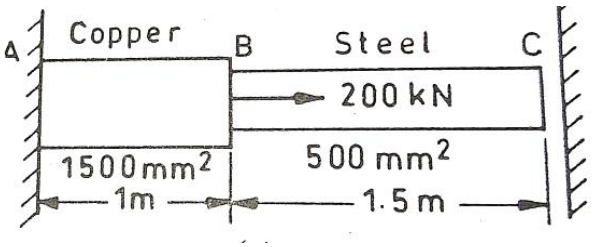
$$[\sigma_{ij}] = \begin{bmatrix} 2 & 3 & 4 \\ 3 & 4 & 1 \\ 4 & 1 & -2 \end{bmatrix} MPa$$

b) If the displacement field in a body is specified as $u_x = (x^2 + 5)\ 10^{-3}$, $u_y = (2y^2\ z)\ 10^{-3}$ and $u_z = (x + 4z)\ 10^{-3}$, determine the strain components at a point whose coordinates are (2, 2, 3). (7)

MODULE II

13. a) Draw Stress-Strain curve for a ductile material and explain the salient points. (7)

b) A compound bar of copper and steel is loaded as shown in figure. Find the stresses in both materials if the copper end is firmly fixed in wall and steel end has a clearance of 0.4mm. Take E_c =115GPa, E_s =210GPa. (7)

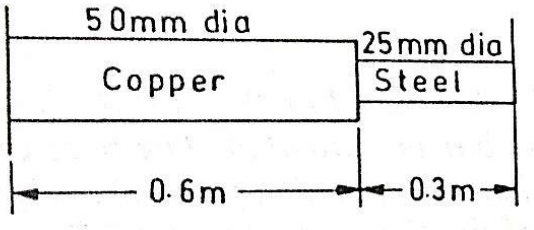


OR

14. a) A bar made of copper and steel as shown in figure is held between two walls. The assembly is free of stress at 50°C. (10)
Find the stress induced in both materials if the temperature falls to 20°C for the following cases.

i. When the supports are perfectly rigid
ii. When the support yield by 0.1mm.

Take E_c =115GPa, E_s =210GPa, α_c=17.5x10^{-6}/°C, α_s=11.7x10^{-6}/°C



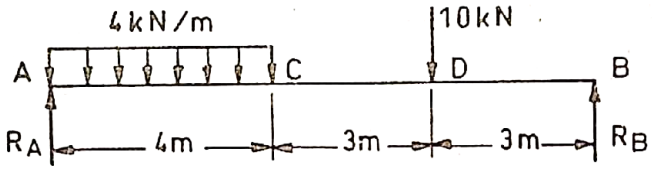
b) For a given material Young's modulus (E) = 80GPa and Poisson's Ratio (ν) = 0.3. Find its Shear modulus (G) and Bulk modulus (K). (4)

MODULE III

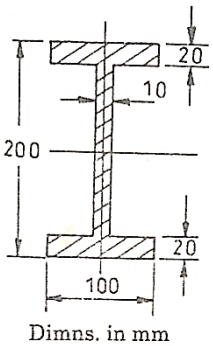
15. A propeller shaft is to transfer a power of 48kW at a speed of 150rpm. If the angle of twist is to be limited to 0.5° in 1 m length of the shaft and G=80GPa, find the minimum diameter for the following cases (14)
   i. When is of solid circular cross section
   ii. When shaft is hollow, with $d_i=3/4d_o$.

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)

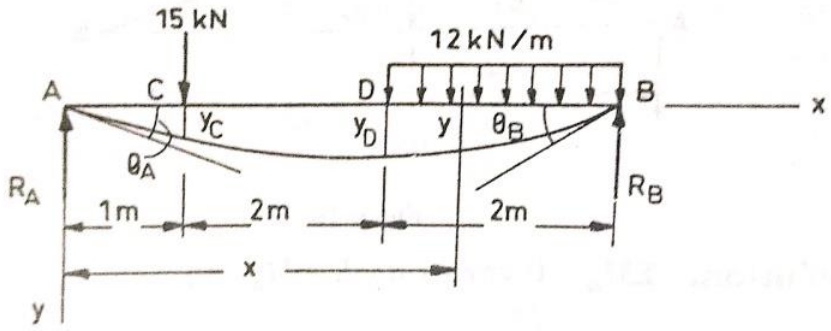


b) The I-section beam shown in figure is simply supported over a span of 5m and caries a concentrated load of 22kN at a distance of 2m from left end. Find the bending stresses at top and bottom of the section at the load point and moment of resistance of the section if allowable bending stress is 130N/mm^2. (7)



MODULE IV

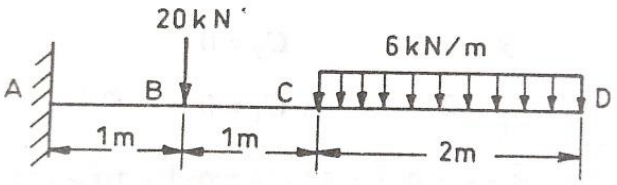
17. A simply supported beam has a span of 5m and the flexural rigidity is EI= 3500kNm^2. If it carries a concentrated load of 15kN at a distance 1m from left end and a udl of 12kN/m over 2m at the right end. Find; (14)
   i. Deflections at C and D
   ii. Slope at the ends
   iii. Maximum deflection and its location



OR

18. a) Derive the expression for elastic strain energy in terms of applied load and material property for (i) Axial load and (ii) Bending load (6)

b) A cantilever carries a point load and UDL as shown in the figure. If $E=210GN/m^2$ and $I= 3.5 \times 10^7 mm^4$. Find the slope and deflection at B, C and D. (8)



MODULE V

19. a) Derive Euler's formula for a column with both ends hinged. (4)

b) A column with both ends hinged has a length of 6m and a hollow circular cross section of outer diameter 90mm and wall thickness 10mm. If $E = 1.5 \times 10^5 N/mm^2$ and crushing stress $\sigma_c=330N/mm^2$, find the load that the column may carry with a factor of safety of 3 according to Euler theory and Rankine-Gordon theory. (10)

OR

20. a) List the various theories of failure. (4)

b) A solid circular shaft is required to carry a torque 45kNm and a bending moment 33kNm. If yield stress σ_y in a simple tension test on the material of the shaft was $230N/mm^2$, find the minimum required diameter of shaft according to (10)

i. Maximum principal stress theory
ii. Maximum principal strain theory

Take Poisson's ratio = 0.33 and factor of safety =2.

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