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1100RAT303122202

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fifth Semester B.Tech Degree (S, FE) Examination June 2024 (2019 Scheme)

Course Code: RAT 303

Course Name: SOLID MECHANICS

Max. Marks: 100 Duration: 3 Hours

PART A

(Answer all questions; each question carries 3 marks) Marks

1		Write equations to find normal and shear stresses in an arbitrarily inclined plane in terms of rectangular components.	3
2		What are invariants of stress and explain why it is called so?	3
3		Write equations relating elastic constants.	3
4		Explain thermal stresses in bars with composite sections.	3
5		With the help of torsion formula explain the term torsional rigidity and its significance.	3
6		State important assumptions made in theory of simple bending.	3
7		Write expressions for strain energy in terms of load, geometry and material properties of the body for axial, bending and torsional loads.	3
8		State and explain Castigliano's second theorem.	3
9		What is slenderness ratio? What is the effective length of columns with both ends pinned?	3
10		What are prevailing natures of failures in (i) short columns, (ii) long columns and intermediate columns?	3

PART B

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

Module -1

11	a)	At a point P in a body, $\sigma_x = 10\ N/mm^2$, $\sigma_y = -5\ N/mm^2$, $\sigma_z = -5\ N/mm^2$ $\tau_{xy} = \tau_{yz} = \tau_{xz} = 10\ N/mm^2$. Determine the normal and shearing stresses on a plane that is equally inclined to all the three axes.	8
	b)	The state of stress at a given point is given by	6

$$\sigma = \begin{bmatrix} 12.31 & 4.20 & 0.84 \\ 4.20 & 8.96 & 5.27 \\ 0.84 & 5.27 & 4.34 \end{bmatrix} \text{MPa.}$$

Determine the values of principal stresses.

12 a) A point in a strained material is subjected to two mutually perpendicular tensile stresses of 200 N/mm^2 and 100 N/mm^2. Determine using Mohr's circle method the intensities of normal and tangential stresses on a plane inclined 30^0 to the plane of major stress. 10

b) The Displacement field for a body is given by $u = (x^2 + y)\, i + (3 + z)\, j + (x^2 + 2y)\, k$. What is the deformed position of a point originally at (3, 1, -2)? 4

Module -2

13 a) A steel rod of 3 cm diameter and 5 m long is connected to two grips and rod is maintained at temperature of 95^0 C. Determine the stress and pull exerted when the temperature falls to 30^0 C if 8

(i) The ends do not yield and

(ii) The ends yield by 0.12 cm

Take modulus of elasticity as $2x\ 10^5$ MN/m^2 and coefficient of thermal expansion as 12×10^{-6} per ^0C.

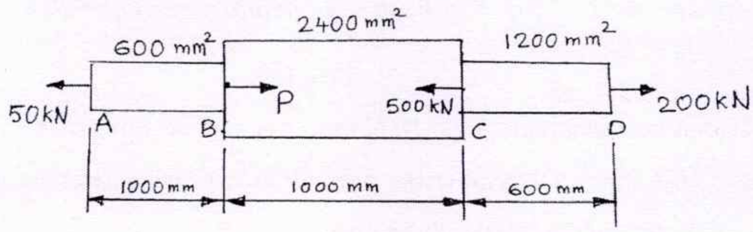
b) Explain the stress-strain relationship of a ductile material under uniaxial tension test with the help of stress-strain curve. 6

14 a) A member ABCD is subjected to point loads as shown in figure. Calculate 7

(i) Force P necessary for equilibrium

(ii) Total elongation of the bar

Take E = 210 GN/m^2



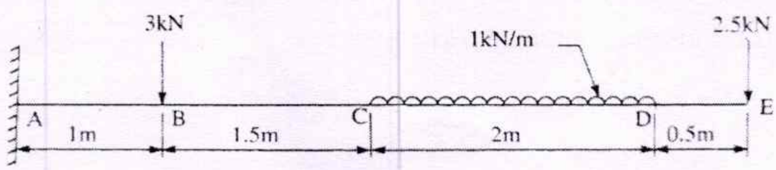
b) A steel rod of 20 mm diameter passes centrally through a copper tube of 50 mm external diameter and 40 mm internal diameter. The tube is closed at each ends by rigid plates of negligible thickness. The nuts are tightened lightly home on the 7 projecting parts of the rod. If the temperature of the assembly is raised by 50 ^{0}C calculate the stresses developed in copper and steel. Take Young's modulus for steel and copper as 200 GN/m^2 and 100 GN/m^2, and coefficient of thermal expansion for steel and copper as 12×10^{-6} and 18×10^{-6} per ^{0}C.

Module -3

15 a) Determine the diameter of solid shaft which will transmit 300 kW at 250 rpm. The maximum shear stress should not exceed 30 N/mm^2 and twist should not exceed 1^0 in a shaft length of 2 m. Take modulus of rigidity of the material of shaft as 1×10^5 N/mm^2. 9

b) Calculate the maximum stress induced in a cast iron pipe of external diameter 40 mm, internal diameter 20 mm and length 4 m, when the pipe is supported at ends and carries a point load of 80 kN at its centre. 5

16 a) Draw shear force and bending moment diagrams for the cantilever beam shown in figure. 10



b) Draw shear force and bending moment diagram of simply supported beam of length L, carrying uniformly distributed load 'w' per unit length over the entire length. What is the maximum value of bending moment acting on the beam. 4

Module -4

17 Find the expression for transverse deflection at the free end of a cantilever beam of length L in which a uniformly distributed load w per unit length is acting over the entire span, and a point load P is acting at the free end. Assume uniform flexural rigidity. Use Castigliano's theorem. Find the value of deflection at free end if the length of the beam is 2 m, uniformly distributed load of 4 kN/m is acting over the entire length, and a point load of 6 kN is acting at the free end of the beam. Take flexural rigidity as 5 MNm^2. 14

18 A steel beam is simply supported at the ends on a span of 8 m, and carries a uniformly distributed load of 8 kN/m on the whole span. In addition, a connection is made to the beam at 5 m from the left end exerts a downward load of 80 kN together with a clockwise couple of 60 kNm acting in the plane of bending of the 14

beam. Determine the location and magnitude of the maximum deflection. Moment of Inertia for the section is 4.79 x 10^8 mm^4, and modulus of elasticity of the beam material is 200 kN/mm^2.

Module -5

19 a) Derive the expressions for crippling load in a column with both the ends hinged. 9

b) Calculate critical load of strut which is made of a bar, circular in section and 5 m long and which is pin-joined at both ends. The same bar when freely supported gives mid-span deflection of 10 mm with a load of 80 N at the centre. 5

20 a) State and explain (i) Rankine's theory for maximum normal stress (ii) Saint-Venant's theory for maximum normal strain and (iii) Hencky-von Mises theory for maximum distortion energy. 9

b) In a metallic body the principal stresses are 35 MN/m^2 (tensile) and 95 MN/m^2 (compressive), the third principal stress being zero. The elastic limit stress in simple tension as well as in compression is equal and is 220 MN/m^2. Find the factor of safety based on the elastic limit if the criterion of failure for the material is the maximum principal stress theory. 5

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