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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S3 (R,S) / S3 (WP) (R,S) / S1 (PT) (S,FE) Examination November 2024 (2019 Scheme)

Course Code: MET201

Course Name: MECHANICS OF SOLIDS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions. Each question carries 3 marks Marks

1	Write strain–displacement relations for a 3D elastic problem.	(3)
2	Differentiate between linear strain and shear strain.	(3)
3	Explain Hooke's law for linearly elastic isotropic material.	(3)
4	Explain the plane stress and plane strain with ONE example each.	(3)
5	Draw the S.F and B.M. diagrams for a simply supported beam of length L carrying a clockwise couple of 'M' Nm at the midsection of the beam.	(3)
6	Differentiate between section modulus and polar section modulus.	(3)
7	Write down the expression for the strain energy stored in a body subjected to (i) axial load (ii) bending moment.	(3)
8	Determine the deflection at the free end of a cantilever beam of length 'l' due to a point load 'P' at the free end.	(3)
9	Define the term equivalent length. What is the effective length of columns with one end fixed and the other end free.	(3)
10	State Haigh's theory for maximum strain energy.	(3)

PART B

Answer any one full question from each module. Each question carries 14 marks

Module 1

11a	The state of stress at a point is characterised by the components, $\sigma_{xx} = 10$, $\sigma_{yy} = 20$, $\sigma_{zz} = 30$, $\tau_{xy} = -20$, $\tau_{yz} = 10$, $\tau_{zx} = 40$ MPa. Determine the values of principal stresses and maximum shear stress.	(8)
11b	If the displacement field is given by $\mathbf{U} = (x^2+y)\,\mathbf{i} + (3+z)\,\mathbf{j} + (x^2-y+2)\,\mathbf{k}$. Write down the strain tensor at the point (3,2,-1).	(6)
12	At a point in a bracket the stresses on two mutually perpendicular planes are 120 N/mm^2 and 60 N/mm^2 both tensile. The shear stress across these planes is	(14)

30 N/mm^2. Using the Mohr's stress circle determine the

(i) principal stresses (ii) maximum shear stress (iii) principal planes and

(iv) plane of maximum shear stress.

Module 2

13 A compound bar of length 400 mm consists of a strip of brass 40 mm wide and 25 mm thick and a strip of steel 40 mm wide and 20 mm thick rigidly joined at ends. If the temperature of the assembly is raised by 80°C, calculate the stresses developed in brass and steel and the extension of the bar. The modulus of elasticity of steel and brass are 210 kN/mm^2 and 110 kN/mm^2 respectively. Take the coefficient of thermal expansion of steel =12 x10^{-6}/°C and the coefficient of thermal expansion for brass = 17.5 X 10^{-6} /°C. (14)

14a A steel rod of 20 mm diameter is enclosed in a copper tube of 40 mm external diameter and 25 mm internal diameter. The tube is closed at each end by rigid plates of negligible thickness. If the assembly is subjected to an axial load of 50 kN, find the stress developed in each material. Take the elastic modulus of copper and steel as 1.2 x10^5 N/mm^2 and 2 x10^5 N/mm^2. (9)

14b Derive the expression for a volumetric strain of a bar subjected to three-dimensional stress. (5)

Module 3

15a Draw the shear force and bending moment diagram for the simply supported beam shown in the Fig 1. (10)

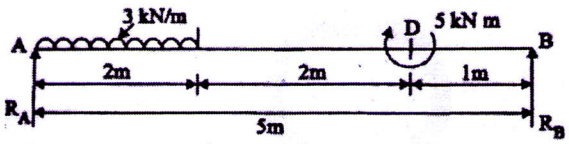

Fig 1

15b Find the maximum bending stress induced in a horizontal simply supported beam made of steel of length 3 m and diameter 20 mm, loaded by a vertically downward force of 200 N at mid-span. Take E_{steel} = 2.1 X 10^5 N/mm^2 (4)

16a A solid aluminum shaft 1.5 m long and 60 mm diameter is to be replaced by a tubular steel shaft of the same length and the same outside diameter such that each of the two shafts could have the same angle of twist per unit torsional moment over the total length. What must the inner diameter of the tubular steel shaft be? Modulus of rigidity of the steel is three times that of aluminium. (10)

16b What is pure bending? Explain with example. (4)

Module 4

17 A beam of length 14 m is simply supported at its ends and carries two-point loads of 90 kN and 60 kN at a distance of 3 m and 9.5 m respectively from the left support. Calculate the deflection under each load using Macaulay's method. Find also the maximum deflection. Given $E = 2.1 \times 10^{11}$ N/m^2 and $I = 64 \times 10^{-4}$ m^4. (14)

18a The cantilever beam supports a uniformly distributed load w and a concentrated load P as shown in Fig 2. Also, it is given that L= 2 m, w = 4 kN/m, P = 6 kN and EI = 5 MNm^2. Determine the deflection at the free end using Castigliano's theorem. (9)

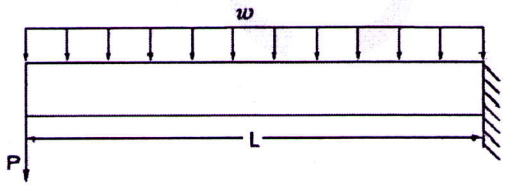

Fig 2

18b Derive strain energy expressions in terms of the geometry, material property and load during (i) Shearing and (ii) Torsion. (5)

Module 5

19 A 1.5 m long column has a circular cross section of 5 cm diameter. One of the ends of the column is fixed in direction and position and other end is free. Taking factor of safety as 3, calculate the safe load using (14)

(i) Rankine's formula, take yield stress as 560 N/mm^2 and α = 1/1600 for pinned ends and (ii) Euler's Formula, Take $E = 1.2 \times 10^5$ N/mm^2.

20 Determine the diameter of a bolt which is subjected to an axial pull of 9 kN together with a transverse shear force of 4.5 kN. Using (14)

1. Maximum shear stress theory
2. Maximum strain energy theory
3. Maximum shear strain energy theory

Yield stress corresponding to elastic limit is 225 MPa, Factor of Safety = 3, and Poisson's ratio = 0.3

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