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Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S5 (S,FE) Examination May 2025 (2019 Scheme)

Course Code: RAT303

Course Name: SOLID MECHANICS

Max. Marks: 100 Duration: 3 Hours

PART A

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

1	Express the stress invariants in terms of cartesian components of stress	3
2	Write the six strain-displacement equations in 3-D Cartesian coordinate system.	3
3	Explain generalized Hooke's law for linear elastic isotropic solids	3
4	Draw the stress strain diagram for brittle material with its salient points.	3
5	Write down flexural formula. What are the assumptions made in theory of bending?	3
6	Differentiate between a cantilever and a simply supported beam.	3
7	What is Macaulay's method? Where is it used?	3
8	State and explain Maxwell's reciprocal theorem.	3
9	Write down the relation between effective length and actual length of the column for the end conditions a) Both ends hinged b) Both ends fixed c) One end fixed and other end is free	3
10	Explain the significance of theories of failure.	3

PART B

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

Module -1

11 a) The state of stress at a point is characterised by the following rectangular stress components $\sigma_x = 20$ MPa, $\sigma_y = 10$ MPa, $\sigma_z = 5$MPa , $\tau_{xy} = -10$ MPa, $\tau_{yz} = -15$ MPa , $\tau_{zx} = -20$ MPa. Find the values of principal stress. 7

b) The state of stress at a point is given below as: $\sigma_x = 10$ MPa, $\sigma_y = 20$ MPa, $\sigma_z = -10$ MPa , $\tau_{xy} = 5$ MPa, $\tau_{yz} = -15$ MPa , $\tau_{zx} = -10$ MPa. Find the normal, tangential stresses and resultant stress vector acting on a plane with direction cosines $n_x=0.47$, $n_y=0.82$, $n_z=0.33$. 7

OR

12 a) The state of plane stress at a point is given by $\sigma_x = 40$ MPa, $\sigma_y = 20$ MPa and $\tau_{xy} = 16$ MPa. Using Mohr's circle determine the (i). Principal stresses and principal planes (ii). Maximum shear stress 10

b) The displacement field for a body is given by $u=(x^2+y)i +(3+z)j+(x^2+2y)k$. Determine the strain tensor at the point (-3, -1, 2) 4

Module -2

13 a) A bar of cross section 8 mm x 8 mm is subjected to an axial pull of 7000 N. The lateral dimension of the bar is found to be changed to 7.9985 mm x 7.9985 mm. If the modulus of rigidity of the material is 0.8×10^5 N/mm^2 , Determine the Poisson's ratio and modulus of elasticity. 5

b) A steel tube of 30 mm external diameter and 20 mm internal diameter encloses a copper rod of 15 mm diameter to which it is rigidly joined at each end. If the temperature is raised to 190 ^{0}C. Calculate the stresses developed in copper and steel. Take E for steel and copper as 2.1×10^5 N/mm^2 respectively. The value of co-efficient of linear expansion for steel and copper is given as 11×10^{-6} per ^{0}C and 18×10^{-6} per ^{0}C 9

OR

14 a) Draw the stress-strain diagram for a ductile material and explain the salient points. 7

b) A straight bar 450 mm long is 40 mm in diameter for the first 250 mm length and 20 mm diameter for the remaining length. If the bar is subjected to an axial pull of 15 KN. Find the maximum axial stress produced and the total extension of the bar. Take E =$2x10^5$ N/mm^2 7

Module -3

15 a) A cantilever beam of length 2m carries a point load of 1 KN at its free end, and another load of 2 KN at a distance of 1m from the free end. Draw the SF and BM diagrams for the cantilever. 10

b) A solid shaft of 150 mm diameter is used to transmit torque. Find the maximum torque transmitted by the shaft if the maximum shear stress induced to the shaft is 45 N/mm^2 4

OR

16 a) A steel plate of width 120 mm and of thickness 20 mm is bent into a circular arc of radius 10 m. Determine the maximum stress induced and the bending moment which will produce the maximum stress. Take E = 2x 10^5 N/mm^2 7

b) A wooden beam 100 mm wide and 150 mm deep is simply supported over a span of 4 m. If shear force at a section of the beam is 4500 N, find the shear stress at a distance of 25mm above the neutral axis. 7

Module -4

17 a) A horizontal girder of steel having uniform section is 14 m long and is simply supported at its ends. It carries concentrated loads of 120 KN and 80 KN at two points 3 m and 4.5 m from the two ends respectively. Moment of inertia for the section of the girder is 16 × 10^8 mm^4 and Es =210 KN/mm^2. Calculate the deflection of the girder at points under the two loads and maximum deflection using Macaulay's method. 14

OR

18 a) Derive the expressions for elastic strain energy in terms of applied load/moment, geometry and material property for the case of a) Axial Force b) Bending Moment c) Shear force d) Torsion — 14

Module -5

19 a) Derive the Euler's formula for long columns with both ends pinned — 9

b) A solid round bar 3m long and 5cm in diameter is used as a strut with both ends hinged. Determine crippling load for the column. Take E as 2.0×10^5 N/mm^2 — 5

OR

20 a) State and explain the following failure theories:

(i) Guest's Theory — 5

(ii) Hencky-von Mises Theory

b) 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 Maximum Principal Stress Theory.Take elastic limit in tension as 225 N/mm^2, Factor of safety =3 and poissons ratio as 0.3 — 9

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