APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIRST SEMESTER M.TECH DEGREE EXAMINATION
Mechanical Engineering
(Machine Design)
04ME6505 - Advanced Mechanics of Solids

Time: 3 hrs Max. Marks: 60

Use of approved data sheets are allowed.

PART A
(Answer all questions. Each question carry 3 marks).

1. Explain the terms:
   (a) Pure shear state of stress
   (b) Stress invariants
2. If the displacement field is given by u_x = Kxy, U_y = Kxy, U_z = 2K(X+Y)z, where K is a constant small enough to ensure applicability of the small deformation theory, write down the strain matrix at Point (1,2,3):
3. Explain Saint Venant's Principle of end effects:
4. Write short notes on stresses for two bodies in line contact:
5. Explain Membrane analogy:
6. Explain the phenomenon of Warping in prismatic bars:
7. Brief on the testing of Viscoelastic materials:
8. Write notes on Tresca and Von Mises Yield Conditions:

PART B
(Each full question carries 6 marks).

9. The stress at a point is given by σ_{xx} = 1 MPa, σ_{yy} = -5 MPa, σ_{zz} = 4 MPa, $\tau_{xz} = \tau_{yz} = 0$ kPa, τ_{xy} = -1 kPa. Determine:
   (a) The traction vector on a plane with normal along 2i-2j+3k,
   (b) The magnitudes of normal and shear stress:

OR

10. Explain the following:
    (a) State of stress at a point with the help of neat sketch. (b) Concept of principal stresses and principal planes. (c) Hydrostatic and Deviatoric state of stresses. (d) Stress transformation.
11. Consider the following stress state acting on a point: σ_1 = 5 MPa, σ_2 = 2 MPa, σ_3 = 1 MPa, $\tau_{12} = \tau_{13} = \tau_{23} = 0$ kPa. Calculate the normal and shear stress on the plane with unit normal, n_x = 0.5, n_y = 0.5. Use 3D Mohr's circle method:

OR

12. Explain Virtual work principle with the help of neat figures:

13. Derive strain compatibility conditions for a 3D elasticity problem: Deduce the same for 2D cases:

OR

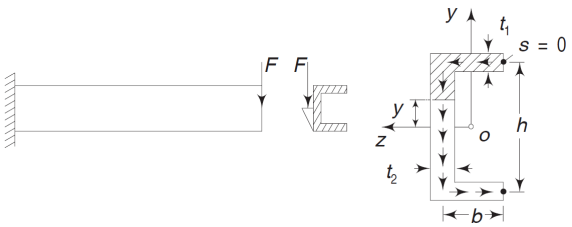
14. Assuming a suitable Airy's stress function, derive the equations for finding stresses in a cantilever beam subjected to a point load at its free end.

15. A fatigue testing machine used to determine fatigue life under rolling contact consists of a steel torroid (body 2) rolling in a steel cylinder (body 1), where $R_1 = 32$ mm, $R_1' = \infty$, $R_2 = 32$ mm, and $R_2' = 20$ mm. For steel, E = 200 GPa and $\nu = 0.29$.
(a) Determine an expression for σ_{max} in terms of P.
(b) Fatigue test results indicate that failure occurs at approximately $N = 10^9$ cycles with σ_{max} = -2758 MPa. Determine the applied load P. Given the minor semi-axis, b is in the direction of rolling.

OR

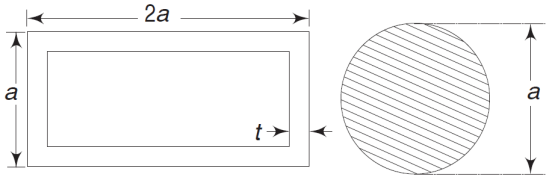
16. A hard steel ball (E = 200 GPa and $\nu = 0.29$) of diameter 50 mm is pressed against a thick aluminium plate (E = 72 GPa, $\nu = 0.33$, and $\sigma_y = 450$ MPa). Determine the magnitude of load P, required to initiate yield in the aluminium plate according to the octahedral shear-stress criterion of failure.

17. Determine the shear stress distribution in a channel section of a cantilever beam subjected to a load F, as shown. Also, locate the shear centre of the section:



OR

18. A thin-walled box section of dimensions 2a x a x t is to be compared with a solid section of diameter a. Find the thickness t so that the two sections have: (a) the same maximum stress for the same torque and (b) the same stiffness.



19. Write short notes on residual stresses:

OR

20. Brief on Kelvin (Voigt) Model. Also draw the Creep-Recovery Response of the Kelvin (Voigt) Model.