M.E. Mechanical Engineering Examination, 2025

(First Year, Second Semester)

Mechanics of Composite Materials

Time: Three hours Full Marks: 100

Answer **all** questions.

1. Define on-axis lamina and off-axis lamina. For a 2-D lamina derive the stress transformation matrix $[T_\sigma^+]$ to determine on-axis stress components from those of off-axis components. Also with usual notations show that $[Q_{ij}]_{off} = [T_\sigma^-][Q_{ij}]_{on}[T_\varepsilon^+]$. (20)

2. Derive the strain transformation matrix $[T_\varepsilon^+]$ for a 2-D lamina to determine on-axis stress components from those of off-axis components. Also with usual notations show that $[S_{ij}]_{off} = [T_\varepsilon^-][S_{ij}]_{on}[T_\sigma^+]$. (20)

3. Define symmetric and anti-symmetric laminates. State the assumptions of Kirchhoff's classical bending theory of thin plates. Express stress [N] and moment [M] resultants of a composite laminate in terms of strain vector and curvature vector. Also write down the expressions for A_{ij}, B_{ij} and D_{ij} of the elasticity matrix of a laminate and identify them. (20)

4. Considering classical laminated plate theory show that

   i) $N_{1,1} + N_{6,2} + q_1 = 0$

   ii) $Q_5 = M_{2,2} + M_{6,1}$

For a simply supported laminated beam subjected to distributed load along its span the equations of equilibrium are given as with usual notations

$$A_{11}\, u_1^0{}_{,11} - B_{11}\, W_{,111} = 0 \quad \text{and}$$

$$D_{11}\, W_{,1111} - B_{11}\, u_1^0{}_{,111} = q(x_1)$$

Derive the expression for determining deflection and load of the laminated beam. (20)

5. Explain the independent failure theories of laminated composite structures. Name the interactive failure theories of composites. Derive the expression for Tsai-Hill-Hoffman criterion for failure of composites. (20)