EX/PG/ME/T/113A/2018

M.E. Mechanical Engineering Examination, 2018

(1st Year, 1st 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 off-axis stress components from those of on-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 cross ply and angle ply laminates. State the assumptions of Kirchhoff's classical bending theory of thin plates. From the first principles derive and express stress [N] and moment [M] resultants of a composite laminate with n number of plies. (20)

4. Define symmetric and anti-symmetric laminates. Considering classical laminated plate theory show that

   i) $N_{6,1} + N_{2,2} + q_2 = 0$

   ii) $Q_{4,1} + Q_{5,2} + q_z = 0$

contd. 2

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. Name the different failure criteria used for the analyses of laminated composite structures. Derive the expression for Tsai-Hill criterion. State whether this criterion is dependent on the nature of load (tensile or compressive). (20)