(b) Define (i) camber line, (ii) angle of attack, for an aerofoil.

(2 + 2 + 4) + (2 + 2) = 12

9. (a) Obtain an expression for the lift produced on a rotating cylinder placed in a uniform flow field such that the axis of the cylinder is perpendicular to the direction flow.

(b) (i) Describe the development of lift force on an aerofoil.
(ii) What is 'stall' of an aerofoil?

6 + (4 + 2) = 12

ADVANCED FLUID MECHANICS
(MECH 3253)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Velocity potential lines and stream lines make ..... angle at crossing point to each other.
(a) 45° (b) 60° (c) 90° (d) none of these.

(ii) For an irrotational flow the condition of irrotationality is satisfied if *Curl* ***V*** is
(a) zero (b) positive (c) negative (d) infinite.

(iii) The expression of doublet strength is
(a) $2a.q$ (b) $2a+q$ (c) $\frac{2a}{q}$ (d) $\frac{q}{2a}$

(iv) For a simple Couette flow, the shear stress distribution between the plates is
(a) linear (b) parabolic (c) hyperbolic (d) none of these.

(v) Plane Poisseuille flow is
(a) purely shear driven flow
(b) purely pressure driven flow
(c) combination of shear and pressure driven flow
(d) none of these.

(vi) For axi-symmetric flow between two large concentric rotating cylinders of radius R_1 and R_2, the radial velocity component V_r of the velocity field is
(a) non zero at inner cylinder radius R_1
(b) non zero at outer cylinder radius R_2
(c) zero everywhere in the flow field
(d) may have any value.

(vii) For obtaining Prandtl's boundary layer equation, the one basic assumption is that, outside boundary layer
(a) inertia force << viscous force
(b) inertia force and viscous force are comparable
(c) inertia force >> viscous force
(d) inertia force and viscous force have no relationship.

(viii) For validation of Stokes law, the value of Reynolds number should be
(a) less than unity (b) more than unity
(c) equal to unity (d) infinite.

(ix) A small disturbance propagates through a compressible fluid medium with sonic velocity
(a) relative to the fluid flow velocity
(b) relative to the disturbance propagation speed
(c) relative to the inertial reference frame
(d) none of these.

(x) From Stokes law, the drag coefficient C_D for flow around a sphere having Reynolds Number Re is given by
(a) $\frac{1}{\mathrm{Re}}$ (b) $\frac{12}{\mathrm{Re}}$
(c) $\frac{24}{\mathrm{Re}}$ (d) independent of Re.

Group – B

2. (a) Prove that stream function is constant along a streamline. Also prove that equipotential lines are orthogonal to the stream lines at all points of intersections.

(b) What is circulation? Compare source flow and sink flow.

(3 + 3) + (2 + 4) = 12

3. (a) Derive the expression of equation of motion for vortex flow $dp = \rho - \frac{v^2}{r}dr - \rho g dz$ where the symbols have their usual meanings.

(b) An open circular tank of 250 mm diameter and 120 cm long contains water up to a height of 70 cm. The tank is rotated about its vertical axis at 310 r.p.m. Find the depth of parabola formed at the free surface of water.

6 + 6 = 12

Group – C

4. (a) From basic principle, derive the relationship between the average velocity and maximum velocity in case of parallel flow between two fixed parallel plates.

(b) Water at 60^0C flows between two large flat plates. The lower plate moves to the left at a speed of 0.3m/s. The plate spacing is 3mm and the flow is laminar. Determine the pressure gradient required to produce zero net flow at a cross section. For water $\mu = 4.7\times10^{-4}$ N-s/m^2 at 60^0C.

7 + 5 = 12

5. (a) Using Navier-Stokes equation in Cartesian coordinate system, obtain Prandtl boundary layer equations for flow over a flat plate, through scale analysis. Mention all the assumptions made, dimensional scales used and boundary conditions for the process.

(b) For Blasius flow over a flat plate, write the Prandtl boundary layer equations, with necessary boundary conditions. What is shooting technique?

9 + 3 = 12

Group – D

6. (a) Define (i) Sonic Velocity (ii) Mach Number and (iii) Mach Cone.

(b) Derive a relation for isentropic compressible gas flow, between
(i) Stagnation temperature and static temperature.
(ii) Stagnation pressure and static pressure.

(2 + 2 + 2) + (3 + 3) = 12

7. (a) Derive 'Area-Velocity' relationship for compressible flow through a duct having variable cross sectional area along the flow direction. Also illustrate the velocity variations for subsonic and supersonic diffusers, using 'Area-Velocity' relationship.

(b) What is meant by critical condition for compressible flow through a duct? Why maximum flow rate is obtained for such critical condition?

(4 + 4) + (2 + 2) = 12

Group – E

8. (a) State Stokes Law for drag on falling sphere. What is terminal velocity? Derive an expression of terminal velocity of a falling sphere in the form $V = \frac{D^2}{18\mu}(\gamma_S - \gamma_L)$. All symbols have their usual meanings.