EX/PG/ME/T/111C/24/2017

Master of Mech. Engg. 1st Sem. Examination, 2017

Subject: Advanced Fluid Mechanics – I

Time : Three hours **Full Marks: 100**

Answer any FIVE QUESTIONS
taking atleast TWO from each group

GROUP A

1.Using the Reynolds' transport theorem obtain the equations for conservation of linear momentum for a fluid element in three dimensional cartesian coordinate system. [20]

2. Using incompressible Navier-Stokes's equation and suitable assumptions, obtain the governing equations for the case of a fluid contained between two concentric circular cylinders both of which are rotating at constant speeds about their axes.The cylinders are assumed to be long compared with their diameter. Obtain expressions for the velocity and pressure distributions in the fluid between the two cylinders. [20]

3. Define *Stokes' Second Problem.* Using incompressible Navier-stokes's equation and suitable justifications, obtain the governing equations and state the boundary conditions. Using a suitable similarity variable obtain the velocity profile. Give a sketch of the velocity profile and obtain an expression for the distance away from the moving boundary within which the fluid is influenced by the motion of the boundary. [20]

4. (a) Using 2D incompressible Navier-Stokes equations and Prandtl's Order of magnitude analysis, obtain the *Bounday Layer Equations.* State the suitable boundary conditions.
(b) Using *Falkner-Skan Solution*, obtain the stream function for boundary layer flow over a wedge. [10+10]

GROUP B

5. a) Discuss the method of separation of variables. Solve an idea fluid flow occurring inside a lid-driven square cavity where top wall is moving at a speed of U_0.
b) Define length scales for coordinate transformation. Write down the length scales for spherical geometry and using them frame the continuity equation for steady ideal spherical flow in terms of velocity potential function. [13+7]

6. a) For incompressible irrotational flow, derive continuity equation in cylindrical coordinate system considering all r, θ and z directions.
b) Solve this continuity equation for the case of flow past a long solid cylinder using the method of separation of variables and find
i) velocity potential function,
ii) velocity components, and
iii) pressure distribution on the cylinder in terms of pressure coefficient. [5+15]

7. a) Define line source and line sink.
b) Derive complex potential function for (i) source flow and (ii) doublet flow.
c) State the method of superposition. Using it and the complex potential, simulate the ideal flow past a solid cylinder in terms of streamlines and equipotential lines. [2+8+10]

8. a) Using complex potential, establish the flow structure (streamlines) for the opposed-jet system consisting of (i) two jets and (ii) three jets. Identify the stagnation point and symmetric streamlines.
b) Explain the use of stream function and velocity potential function in connection with ideal flow and real flow. Prove that they intersect each other orthogonally. [12+8]