

**BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR**  
**M.E. 1ST SEMESTER ( AE and AM ) FINAL EXAMINATION, 2013-2014**  
**ADVANCED MECHANICS OF FLUIDS I (AM-906)**

**Full Marks: 70**

**Time: 3 Hours**

**All questions carry equal marks.**

**Answer any SIX questions.**

- 1.(a). Prove that the velocity vector  $V = (4x/(x^2+y^2))i + (4y/(x^2+y^2))j$  satisfies the continuity equation at every point except at the origin of the co-ordinates.
- 1.(b). What is meant by a singular point? Describe, with the aid of neat diagrams, some examples of singular points in fluid flows.
- 1.(c). A velocity vector is given by  $V = (-x)i + (2y)j + (5-z)k$ . Find the equation of the streamline through (2,1,1).
- 1.(d). Does the velocity vector  $V = (5x)i + (5y)j + (-10z)k$  satisfy the continuity equation?
- 2.(a). Prove that the velocity potential and stream function satisfy the Cauchy-Riemann equation.
- 2.(b). A velocity potential in two dimensional flow is  $\Phi = y + x^2 - y^2$ . Find the stream function for this flow.
3. Derive the continuity equation for a compressible fluid in three dimensions in Rectangular Cartesian and in cylindrical co-ordinates. Also, derive the continuity equation for a compressible fluid in three dimensions in vector form.
4. Derive the Euler's equations in three dimensions in Rectangular Cartesian and in cylindrical co-ordinates for an ideal fluid.
5. (a) Describe, with the aid of neat diagrams, some elementary flow patterns in ideal fluid flow. What is a half body? What is d'Alembert's paradox?
- 5.(b) Describe, with the aid of neat diagrams, what is meant by conformal mapping. Describe, with the aid of neat diagrams, what is meant by Schwartz-Christoffel transformation.
6. Derive the the velocity profile, shear stress profile, discharge and mean velocity for laminar flow of a viscous fluid for the following cases :
  - a. Fluid flowing through a cylindrical pipe.
  - b. Fluid flowing through the annulus between a cylindrical pipe and a concentric fixed cylindrical shaft inside the cylindrical pipe.
7. Describe, with the aid of neat diagrams, what is meant by boundary layers, regular perturbations and singular perturbations. Describe, with the aid of neat diagrams, what is meant by boundary layer separation. Describe, with the aid of neat diagrams, the importance of the angle of attack between the leading edge of an aerofoil and the freestream in the context of boundary layer separation.

8. Describe in detail, with the aid of an example and neat diagrams, how a fluid mechanics problem is solved by the Finite Element method with special reference to
- Dirichlet and Neumann boundary conditions.
  - Lagrangian and Hermitian interpolation.
  - Well-posed and Ill-posed boundary conditions.
  - Methods of increasing the accuracy of a Finite Element scheme.