AD

INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR
Date: FN/AN, Time: 2 Hrs, Full Marks: 60, Deptt.: Aerospace Engineering
No. of students: 51, Mid Spring Semester Examination
Sub. No. : AE 21002, Sub. Name: Low speed Aerodynamics
2nd Year Btech students

Short questions: (2 marks each)

1. Irrotationality condition leads to potential flow. Explain how.

2. Explain what is continuum hypothesis that is used in fluid dynamics. Does it hold in outer atmosphere?

3. Potential flow theory cannot predict the drag experienced by a cylinder placed in an uniform flow. Why?

4. Is a cricket ball an example of a streamlined body? Explain.

5. Explain why a rotating cylinder placed in a wind tunnel experiences lift.

6. Give examples of a) incompressible constant density flow b) incompressible variable density flow c) compressible flow

7. Why are nondimensional coefficents like C_L, C_D used in aerodynamics?

8. How can you predict the viscous flow past an airfoil?

9. State the assumptions made in thin airfoil theory.

10. In thin airfoil theory, a symmetric airfoil is treated in the same way as a flat plate. Explain.

Regular questions:

1. a) Consider 1-d Navier-Stokes equation for incompressible, constant density flow given below:

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} = -\frac{1}{\rho}\frac{\partial p}{\partial x} + \frac{\mu}{\rho}\frac{\partial^2 u}{\partial x^2}$$

Nondimensionalize this equation using u_o, L, p_o as reference velocity, length and pressure.

b) From the nondimensional Navier-Stokes equation, state which nondimensional number governs incompressible, constant density flows.

c) Under what condition can you get the unsteady Euler equation from the above equation?

d) Starting from the steady Euler equations derive Bernoulli's equation valid along a streamline. (12 marks)

2. Derive Laplace equation for velocity potential. Show that if the functions A and B are solutions of two dimensional Laplace equation, then the function $C = 5A + B$ is also a solution of the Laplace equation. Which property of Laplace equation makes this possible? How is this property used in synthesis of potential flows? (5 marks)

3. Relate circulation along a closed curve in a fluid to the vorticity of the fluid inside the curve. Now show that vorticity at the center of an irrotational vortex is infinite.(5 marks)

4. Derive the expression of the streamfunction of flow past a circular cylinder without circulation. This flow is obtained by superposing a doublet and a uniform flow. Explain the concept of dividing streamline. What will happen if we increase the doublet strength? Derive the expression for coefficient of pressure on the cylinder surface. Explain why the lift and drag in this flow is zero. (12 marks)

5. a) State Kutta-Joukowski theorem. Is it applicable to an elliptic cylinder?

b) How can you predict the lift experienced by an arbitrary shaped airfoil placed in a potential flow? (6 marks)