INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date: FN/AN, Time: 2 Hrs, Full Marks: 30, Deptt.: Aerospace Engineering
No. of students: 46, Mid Spring Semester Examination
Sub. No. : AE 21002, Sub. Name: Low speed Aerodynamics
2nd Year Btech students

Short questions: (2 marks each)

1. Give examples of a) Constant density incompressible flow b) Variable density incompressible flow c) Compressible flow. Discuss briefly.

2. Potential flow theory gives reasonable estimates of lift on airfoils at high Reynolds numbers. Why?

3. Explain how the irrotationality condition leads to a potential flow.

4. Explain D'Alembert's paradox for potential flow over cylinders, airfoils etc.

5. A rotating cylinder placed in a wind tunnel experiences lift. How can you explain this without using potential flow arguments?

Regular questions: (5 marks each)

1. a) Start from incompressible Navier-Stokes equations, nondimensionalize them using velocity U, and Length L. Show that the viscous term is negligible at very high Reynolds number.

b) Starting from the steady Euler equations derive Bernoulli's equation valid along a streamline.

c) Starting from the steady Euler equations, derive Bernoulli's equation valid for any two points in an irrotational flow.

2. Show that in a 2 dimensional irrotational vortex, the vorticity at the center is infinite. Explain why the circulation in the vortex along a closed curve containing the origin is nonzero.

3. a) Show that if the functions A and B are solutions of 2 dimensional

Laplace equation, then the function $G = 4A + 3B$ is also a solution of the Laplace equation. Why this is so? What consequence does this property of Laplace equation have on potential flows?

b) Which boundary condition on the wall surface can be imposed on the velocity in a potential flow- no-slip condition or impermeability condition? Explain.

4. The velocity field about a cylinder of radius R placed in a uniform potential flow (velocity V_{inf}) is given by

$$V_r = V_{inf}cos\theta[1 - (R^2/r^2)], V_\theta = -V_{inf}sin\theta(1 + (R^2/r^2))$$

Show that the coefficient of pressure on the cylinder surface is given by

$$C_p = 1 - 4sin^2\theta$$

Show -by integrating the pressure on the cylinder surface- that lift and drag in this case are zero.