19-02-2018 (FN)

Desk

INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR
Date: FN/AN, Time: 2 Hrs, Full Marks: 50, Deptt.: Aerospace Engineering
No. of students: 50, Mid Spring Semester Examination
Sub. No. : AE 21002, Sub. Name: Low speed Aerodynamics
2nd Year Btech students

Short questions: (2 marks each)

1. What is an inviscid flow? Under what conditions can a flow be considered inviscid?

2. What are the different components of drag that an airfoil experiences in an incompressible flow?

3. An airfoil is placed in an uniform viscous flow at an angle of attack of 90 degree. Sketch the streamline pattern of the flow.

4. Give examples of a) incompressible variable density flow b) compressible flow

5. Why should we use nondimensional coefficients like C_L. C_D in aerodynamics?

Regular questions:

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

$$\frac{\partial u_i}{\partial t} + u_j \frac{\partial u_i}{\partial x_j} = -\frac{1}{\rho}\frac{\partial p}{\partial x_i} + \frac{\mu}{\rho}\frac{\partial^2 u_i}{\partial x_i^2}$$

b) Derive Bernoulli's equation from the above equation valid between any two points in a flow. State the assumptions you have made.(10 marks)

2. a) Explain what is meant by circulation. Relate circulation along a closed curve in a fluid to the vorticity of the fluid inside the curve.
b) State Kutta-Joukowski theorem. A vortex placed at a fixed location in an uniform flow has circulation Γ. What is the lift experienced by this vortex? (10 marks)
3. Derive the expression of the streamfunction of flow past a circular cylinder with circulation. This flow is obtained by superposing a doublet, a vortex

and a uniform flow. Explain the concept of dividing streamline. There is no unique potential flow solution for this problem. Why? Explain why the lift in this flow is non-zero. (10 marks)

4. a) Explain what is a vortex sheet. Show that the circulation per unit length in a vortex sheet is equal to the difference in tangential velocity across the sheet.

b) How can you predict the lift experienced by an arbitrary shaped airfoil placed in a potential flow using the vortex sheet concept?

c) What are the assumptions of thin airfoil theory?(10 marks)