INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date: 19/04/2018 FN, Time: 3 Hrs, Full Marks: 100, Dept: Aerospace Engg
No. of students: 50, End Spring Semester Examination
Sub. No. : AE 21002, Sub. Name: Low speed Aerodynamics
2nd Year B Tech students

1. a) What are source sheets and vortex sheets? Can vortex sheets occur in viscous flows found in nature?

b) Both thin airfoil theory and vortex panel methods use vortex sheets. Explain how. Explain clearly the steps involved in a vortex panel method. Do you find similarities between this method and thin airfoil theory?

c) Is it possible to use vortex panel methods for thin airfoils? Explain. (15 marks)

2. a) Explain why the concept of horseshoe vortex is used for finite wing.

b) What are the difficulties of using a single horseshoe vortex in this case?

c) What is a bound vortex and a lifting line?

d) Assuming a variable circulation along the lifting line, derive expressions for downwash and induced angle of attack.

e) Now write the expressions of downwash and induced angle of attack for an elliptic lift distribution. (15 marks)

3. a) State how the induced drag coefficient is related to the lift coefficient for elliptic lift distribution and for general lift distribution.

b) Lifting line theory cannot be used for swept wings, delta wings. Explain why.

c) Explain a numerical procedure which may be used for lift calculation for potential flow over swept wings, delta wings etc.

d) Is it possible to compute friction drag using potential flow computation methods? Which computational methods may be used for such purpose? (15 marks)

4. a) What are aircraft trailing vortices? How are they formed? What difficulties are faced by busy airports because of these trailing vortices?

b) How is it possible to minimize the three-dimensional effects on a finite wing model placed in a wind tunnel?

c) Birds, airplanes often fly in formation. What are the benefits of formation flight? Explain in detail with a sketch.

d) According to thin airfoil theory, flow over a thin symmetric airfoil is equivalent to that over a flat plate. Explain in detail. (15 marks)

5. (a) What is Newtons's law of viscosity?

(b) Plot the stress versus strain rate for a Newtonian and Non Newtonian fluid. (5 marks)

6. (a) What is meant by a fully developed flow?

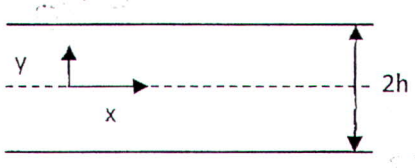
(b) Draw the velocity profile in the entrance region of a pipe and explain the flow features. (5 marks)

7. (a) Using control volume analysis obtain the velocity profile for Couette flow with non zero pressure gradient.

(b) Make a sketch to show the influence of pressure gradient on the velocity profile.

(c) Obtain the condition for which shear stress on the stationary wall becomes zero. What is the physical significance of such a condition? Can such condition occur on an airfoil? (15 marks)

8. A two dimensional Newtonian flow takes place through a parallel channel of height '2h' along the x direction as shown in the figure below. Assuming parallel flow, obtain the velocity profile u(y) by applying Navier Stokes equations. Obtain an expression for maximum velocity. (10 marks)



9. Sketch the boundary layer on a flat plate and explain its important features. (5 marks)