Ex/ME/T/222/2017(Old)

B.E. Mechanical Engineering Second Year Second Semester Examination 2017 (Old)
Subject: Fluid Mechanics II
Time: Three hours Full Marks: 100

Answer any five questions.
Assume any data, if necessary.

1. a) Neatly draw the growth of boundary layer for flow over a flat surface and find the expression for "displacement thickness" and "momentum thickness" in terms of local boundary layer thickness.

   b) Find the expression for Von-Karman's Momentum Integral Equation for two-dimensional, incompressible boundary-layer flow over a flat surface with zero pressure gradient. (10+10)

2. a) The velocity distribution in a laminar boundary layer flow over a smooth flat surface under zero pressure gradient is given by:

   $\frac{u}{U_\alpha} = 2\eta - \eta^2$, where $\eta = \frac{y}{\delta}$ and the symbols have their usual meanings. State the nature of velocity distribution. Stating the Von-Karman's Momentum Integral Equation for two-dimensional, incompressible boundary-layer flow over a flat surface with zero pressure gradient, obtain the expressions for the boundary layer thickness and momentum thickness in terms of local Reynolds Number.

   b) Let air with a free stream velocity of 1.5 m/s is flowing over a flat surface with zero pressure-gradient. Assume that the boundary layer flow remains laminar up to the local Reynolds number of $2X10^5$. Determine the length of the plate till the flow remains as laminar and the total drag force acting on the plate. Assuming kinematic viscosity of air (ν_{air}) is 1.0×10^{-5} m^2/sec. (12+8)

3. a) What is source? Find the expression for stream-function for a source.

   b) With a net sketch, explain how do you get the half-body by combination of a source and uniform flow? (8+12)

4. a) What is Doublet? Obtain the equation for stream-function for a Doublet flow.

   b) Show that the combination of a uniform flow and doublet represents a flow past a stationary circular cylinder. (8+12)

5. a) Using Buckingham-π theorem, determine the expression for the Drag-Force F_D experienced by a sphere of diameter **D** when travelling at velocity **V** through a fluid of mass density ρ and dynamic viscosity μ.

   b) An 1:8 model of a boat is towed in water of kinematic viscosity 10-6 m2/s. What should be the kinematic viscosity of the liquid to be used for the prototype to maintain dynamic similarity, if the resistance to boat is governed, mainly, by the viscous and gravity effects? (12+8)

6. a) Obtain the expression for the local sonic velocity through a compressible fluid due to weak disturbances.

   b) What is Mach number? Establish the effect of Mach number on compressibility and hence, show that for Mach number $M < 0.3$, air may be treated as an incompressible fluid. (10+10)

7. **a)** Establish the expression between the local Mach number **M** and the local area **A** for compressible flow and highlights the effect of flow area on Mach number **M** in reference to a converging-diverging flow passage.

   b) Air is to flow through a convergent-divergent nozzle at 1.2 kgm/s from a large reservoir in which the temperature is at 20°C. At the nozzle exit, the pressure is 14 kPa and the Mach number is 2.8. Assuming isentropic flow, determine the throat and exit areas of the nozzle, the pressure in the reservoir and at the throat. Also calculate the temperature and velocity of air at the nozzle exit. (10+10)

8. What is the prerequisite condition for shock to occur for compressible flow? Establish the relationship between the up-stream Mach number (M_1) and downstream Mach number (M_2) for a normal shock in a compressible flow. (20)

9. Write short notes on any <u>Two</u> from the following: (2x10)

   a) Boundary layer separation.

   b) Mach cone and Mach angle.

   c) Back pressure effect on the performance of a converging diverging nozzle.