Bengal Engineering and Science University, Shibpur
B. E. (Mech.) Part-II 4th Semester Final Examination, 2013

Mechanics of Fluids (AM 407)

Time: 3 Hrs. Full Marks: 70

Use separate answer scripts for each half
Answer any three from each half
All questions are of equal value
Two marks are reserved for neatness in each half

First Half

1. Derive the equation of the principle of the conservation of linear momentum for an incompressible laminar flow in the z-direction using cylindrical coordinate system. State and apply all the assumptions required.

2. a) Derive the expression for velocity distribution for incompressible Poiseuille flow. State and apply all the assumptions required.

   b) Show that frictional coefficient at wall of the above flow is **12/Re**.

3. a) Show that the ratio of pressure at sonic condition to total pressure at a point in a compressible flow of air is 0.528.

   b) Derive the expression for Prandtl relation for a compressible flow.

4. By taking a third order velocity profile determine the displacement thickness, momentum thickness and coefficient of drag in terms of streamwise coordinate and Reynolds number for a two dimensional, incompressible and laminar flow over a flat plate held parallel to the flow.

5. a) Using Blasius expression for wall shear stress and taking seventh root profile for velocity distribution, derive the expression for coefficient of drag for a turbulent boundary layer flow ($Re_L < 10^7$) over a smooth flat plate considering the critical Reynolds number (Re_x) to be 500,000. L is the length of the plate and x is the stream-wise direction along the plate.

SECOND HALF

6.(a) A pipe of diameter 200 mm and length 2 km connects two reservoir having a difference of water level of 20 m. Determine the discharge through the pipe. Also find the increase in discharge if an additional pipe of diameter 200 mm is attached in parallel to the existing pipe to the last 1.2 km length of it. Neglect minor losses and take friction factor f=0.06.

(b) Find the maximum power transmitted by a jet of water discharging freely into atmosphere from a nozzle fitted at the end of a pipe of diameter 100 mm and 300 m long. The available head at the base of the nozzle is 90 m. Prove any formula you use.Take friction factor f = 0.04 and C_v for the nozzle as 0.94.

7.(a) What power would be required to pump 550 lit/sec of water of dynamic viscosity 1.02 centipoise through a 500 mm diameter smooth pipe over a length of 2 km ? Use Blassius equation for determination of friction factor, if necessary.

(b) An oil of density 950 kg/ m^3 and dynamic viscosity 1 Pa-sec is carried at the rate of 0.14 m^3/sec through a pipe of diameter 300 mm and 1 km length. Due to increase in environmental temperature the dynamic viscosity of oil changes by a factor of 8. If the same quantity of oil is to be coveyed through the pipe, compare the cost of electric power consumed for pumping the oil through the pipe in the two cases. Assume friction factor f = 0.0385 if the flow is turbulent.

8. In a pipe network, four junctions A, B, C and D are connected by five pipes AB, AC, AD, BC and CD. Taking $h_f = r\,Q^2$, values of pipe resistance 'r' for the five pipes AB, AC, AD, BC and CD are 2, 1, 4, 2 and 3 units respectively. There are inflows of 50 units each at A and B and outflows of 25 and 75 units from C and D respectively. Determine the flow rates (with direction of flow) through each pipe in the network.

9(a) Starting from fundamentals derive an expression for time of establishment of flow in a pipe.

(c) Two pipes, each having a length of 3 km and diameter of 300 mm (f=0.024), are connected in parallel to each other between two reservoirs. Each reservoir has a uniform cross sectional of area 0.25 km^2. Find the time taken for the difference of water levels between the two reservoirs to fall from 30 m to 25 m.

10(a) Starting from fundamentals deduce an expression for head loss due to friction in an effuser.

(b) A fire hose 75 mm in diameter and 500 m long discharges water from a nozzle situated 7 m above a hydrant to which the hose is connected. Diameter of jet is 20 mm, f = 0.018 and C_v for the nozzle is 0.94. The pres e at the hydrant is 785 kPa. Determine the velocity of the jet, the frictional head loss in the hose and the power of the jet.