**Department of Chemical Engineering, IIT Kharagpur**

**Fluid Mechanics (CH 20001) End-Semester Examination, 2013**

## 2nd year B.Tech (H)/M.Tech (Dual) No. of Students 84, Time 3 Hrs., Full Marks 50

## Open Book Examination

## Only the two textbooks by the following sets of authors are allowed

## i) Fox & McDonald and ii) Bird Stewart & Lightfoot

## Any other book(s), photocopies of text books and class notes are not allowed

There may be handwritten notes on the pages of the book but sharing of books is NOT allowed.

**Q1.a** Large hovercrafts have been used to transport passengers and vehicles across the English Channel since 1960. They can carry 384 passengers and 50 vehicles. They are supported by a cushion of air, provided by large fans. The hovercraft is 30 m wide and 70 m long, and weighs 3 × 105 kg at full load. Calculate the air pressure to be generated for supporting the hovercraft. **3 Marks**

**Q1.b** Given a choice of a Newtonian fluid and a Bingham plastic, which one will you prefer for painting a vertical wall, and why? What velocity distribution is expected for flow of Bingham plastic through a tube with overall Reynold’s number falling in the laminar region? Explain with a rough sketch. **3 Marks**

**Q1.c** A student claims to have made a fountain with a fine capillary by just dipping it in water. (S)he imposed a restriction that the length of the capillary has to be less than 5 cm. Is it feasible? If so, calculate the diameter of the capillary. Another student suggests that the performance of the fountain can be improved by adding some surfactant to water. Comment on the viability with reason. **3 Marks**

**Q2.** For turbulent flow through a pipe, the universal velocity profile is given as

, where = the shear velocity, and y is the distance from the wall. Find the distance from the wall (i.e. y/R) at which the local velocity is equal to the average velocity through the pipe. **4 Marks**

**Q3.** A source with strength 0.2 m2/s, and a vortex with strength 1.0 m2/s are located at the origin. Determine the equations for potential and stream functions. What are the velocity components vr and vθ at (x = 1m, and y = 0.5 m)? **4 Marks**

**Q4.** If the resistive force R, experienced by a partially submerged body depends on the velocity V, length of the body *l*, viscosity of the fluid μ, density of the fluid ρ, and acceleration due to gravity g, obtain the dimensionless numbers involved in the expression of R using Buckingham Π theorem. **4 Marks**

1.1 m

1.6 m

5 m

**Q5.** A closed tank 5 m long, 1.8 m wide and 1.6 m deep

Initially contains water to a depth of 1.1 m. The top has

an opening in the front part to have air space at

atmospheric pressure. If the tank is given an

acceleration of 2.5 m/s2 along its length, draw the

liquid level in the tank, showing clearly all the dimensions.

**4 Marks**

**Q6.** A sealed journal bearing is formed from two concentric cylinders. The inner and outer radii of the cylinders are 25 and 26 mm, the journal length is 100mm, and it turns at 2800rpm. The gap is filled with oil of density 800 kg/m3 in laminar motion. The torque needed to turn the journal bearing is 0.2 Nm. Calculate the viscosity of the oil. Will the torque increase or decrease with time? Why? **5+1 Marks**

**Q7.** Water from a jet strikes a moving (to the right with a velocity equal to U) vane as shown in the adjoining figure. The jet diameter is 50 mm and its velocity is 20 m/s. Find the force needed to maintain a constant speed of the vane equal to 5 m/s. **7 Marks**

**Q8.** A pipe of 6 cm in diameter, 1000 m long and with f = 0.018 is connected in parallel between two points M and N with another pipe 8 cm in diameter, 800m long and having f = 0.02. A total flow of 20 L/s enters the parallel pipes through the division at M to rejoin at N. Estimate the division of flow in the two pipes. **4 Marks**

**Q9.** Calculate the power requirement to pump water at 60 L/s from a supply tank through a 100 mm diameter and 25 m long pipeline into the storage tank. The liquid level of storage tank is 9 m above that of the supply tank. Four 900 elbows, two fully open gate valves are present in the pipeline. The average thickness of the surface roughness of the pipe is 0.25 mm. Following head loss coefficient (K) are available - entrance loss: 0.5; exit loss:1.0; 900 elbow:1.8; fully open gate valve: 0.3. The friction factor can be calculated from:

 **8 Marks**