## Department of Chemical Engineering, IIT Kharagpur

## Fluid Mechanics (CH 20001) End-Semester Examination, 2014

## 2nd year B.Tech (H)/M.Tech (Dual) No. of Students 86, 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. The student must retain the possession of his/her book(s) during the entire examination.

**Q1.** An incompressible fluid flows between two porous, parallel flat plates as shown in the figure. An identical fluid is injected at a constant speed *V* through the bottom plate and simultaneously extracted from the upper plate at the same velocity. Assume the flow to be steady, fully-developed, the pressure gradient in the x-direction is a constant, and neglect body forces. Determine appropriate expressions for the y component of velocity and show that the x component of velocity can be expressed as

**9 Marks**

**Q2.** A plane jet of water strikes a splitter vane and divides into two flat streams (m2 and m3) as shown, where A is the cross sectional area of the jet and V is its velocity. Find the mass flow rate ratio required to produce zero net vertical force on the splitter vane. Determine the horizontal force that must be applied under these conditions to maintain the vane motion at steady speed (U). Assume no friction and pressure forces, negligible mass of water on the vane, steady and uniform flow at each section and no change in speed of the jet with respect to the vane.

**8 Marks**

**Q3.** During the hurry to reach a fire on time, a fireman mistakenly picked a nozzle whose diameter is the same as that of the hose. The length of the hose is 30 m, the diameter of is 8 cm and the roughness of the hose is 0.0008m. He has to deliver a jet of water to a height of 10 m above the ground. The water jet leaves the hose at an angle of 60o to the horizontal. Evaluate the minimum head to be developed by the pump that draws water from a reservoir (at the same level of the hose) maintained at atmospheric pressure.

His fellow fireman has later brought a reducing nozzle of 2.5 cm exit diameter and advised his friend to attach it to the exit of the hose, suggesting that this would significantly cut down the pump head requirement. You as an expert in fluid mechanics are entrusted to resolve this. Your opinion should be based on quantitative assessment of the situation. You can neglect minor losses for both the cases.

Hose

**4+4=8 Marks**

**Q4.** The velocity distribution of a wave motion in a rotating fluid is given by

Where A, α, and Ω are constants with dimension of {Lt-1}, {L-1}, and {t-1} respectively. What is the acceleration in this flow?

**5 Marks**

***Continued…..***

**Q5.** A point source of strength m is located at the point (x=1, y=2, z=3). There is a wall at x=0, and a second wall at y=0. What is the complex potential for this flow? Hint: A wall can be simulated by considering image source(s) of same strength(s) on the opposite side of the wall, as if the wall acts as a mirror. **5 Marks**

**Q6.** A horizontal venturimeter with inlet and throat diameters of 0.3 m and 0.1 m respectively is found to have inlet pressure of 130 kPa (absolute) and the pressure at the throat of 410 mm of Hg (absolute) during a flow run. If 3% of the total head is lost between the inlet and the throat due to eddies, calculate the flow rate and the *CV* of the venturimeter. Do you see any use of this instrument in generating a vacuum in a chamber, when the instrument in the flow line is not used for flow rate measurement? Explain. **5 Marks**

**Q7.** An open cylindrical (thin-walled) drum with a diameter of 0.5 m and a height of 1.2 m is turned upside down in the atmosphere and then submerged in a liquid so that it floats partially submerged upside down, with air trapped inside. If the drum weighs 70 kg and it floats with 0.5 m above the surface of the liquid, what is the density of the liquid? **5 Marks**

0.5 m

0.25 m

1.5 m

**Q8.** A rectangular tank contains water (of density 1000 kg/m3) and

oil (of density 900 kg/m3) up to the heights 0.25 m and 0.5 m

respectively. The dimensions of the base of the tank are 1.5 m X 1.5 m.

Calculate

1. the force at the base of the tank
2. the resultant force on the side of the tank, perpendicular

to the plane of the paper

1. the centre of pressure (point of application of the resultant force)

in Point(ii) above **5 Marks**