**Department of Chemical Engineering, IIT Kharagpur**

**Fluid Mechanics (CH 20001) Mid-Semester Examination, Autumn 2012**

## Open Book Examination

## Only the two textbooks by the following authors are allowed – i) Fox & McDonald and ii) Bird, Stewart & Lightfoot. Other books, photocopies of the text books, even in bound forms, and class notes are not allowed

**Total Marks = 30, Duration = 2hours**

**Q1.** In a game of air hockey, the ball (called puck, which are slim discs made of resin) floats above a thin film of air on a table. The tables will typically have some sort of machinery that produces a cushion of air on the play surface through tiny holes, with the purpose of reducing [friction](http://en.wikipedia.org/wiki/Friction) and increasing play speed. The idea is to hit the puck hard such that it travels fast towards the opponent’s goal while floating on air. The mass of one such puck is 30 g, with a diameter of 100 mm. The air film (of viscosity 1.75 x 10 – 5 N.s/m2) under the puck is 0.1 mm thick. Calculate the time required after impact for the puck to lose 10 percent of its initial speed. Assume that the other (top) surface of the puck does not contribute to its slowing down. (**Marks = 6)**

**Q2.** Consider two concentric cylinders with a Newtonian liquid of constant density, ρ, and constant dynamic viscosity, μ, contained between them. The outer pipe, with radius, *R*o, is fixed while the inner pipe, with radius, *R*i, and mass per unit length, *m*, falls under the action of gravity at a constant speed. There is no pressure gradient within the flow and no swirl velocity component. Determine the vertical speed, *V*, of the inner cylinder as a function of the following (subset of) parameters: *g*, *R*o, *R*i, *m*, ρ, and μ. The space between the two cylinders is **not** ‘too small’ compared to the radii of the cylinders concerned. (**Marks = 9)**

**Q3.** A stick (specific gravity 0.4) is anchored to the bottom of a water tank. The dimensions of the stick are 10 cm X 10 cm X 275 cm. The stick can freely rotate around the anchor point. The depth of water in the tank is 60 cm. Find the angle at which the stick floats. Hint: Take moments of weight and buoyancy forces about the anchor point to eliminate the unknown anchor force. The sum of the two moments is zero at equilibrium. **(Marks = 4)**

**Q4.** An open tank 6m long, 2.4 m deep and 3.6 m wide contains oil of specific gravity 0.85. When the tank is at rest, the height of oil level from the floor of the tank is 1.2 m. If the tank is accelerated along the length-axis on a horizontal track at a constant acceleration of 4.8 m/s2, calculate the position of the oil surface, and the amount of spill, if any from the tank. **(Marks = 4)**

3 mm

9 cm

9 cm

**Q5.** Two rectangular glass plates, identical to each other are taped together so that the vertical edge of one plate touches the corresponding edge of the other plate. Along the opposite edges, a 3mm diameter rod is placed as spacer, vertically between two plates. The gap between the two plates forms a wedge with sides 9 cm, 9 cm, and 3 mm. If the assembly is dipped in a shallow pool of liquid of specific gravity 0.8, contact angle 25°, and surface tension 0.07 N/m, what would be the rise or dip of liquid level at a distance x from the taped edge? What would be the shape of liquid-air interface? **(Marks = 4)**

**Q6.** Find the stream function associated with the two dimensional incompressible flow

**(Marks = 3)**