BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR
B.E. 3RD SEMESTER (ME) FINAL EXAMINATIONS, 2011
Fluid Mechanics I (AM 305)

Full Marks: 70 **Time: 3 hrs**

(i) Answer any **six** questions taking **three** from **each half**
(ii) All questions carry equal marks
(iii) **Do not** write anything on this question paper

First Half

1. a) Derive the three-dimensional continuity equation in cylindrical coordinate.

   b) Two large plane surfaces are 10 mm apart and the gap contains oil of viscosity 0.6 Pa.s. A 'thin' plate located 4 mm above the bottom surface is to be pulled through the gap at a constant velocity of 0.3 m/s. Neglecting edge effects, estimate the force required for pulling the plate. Area of the plate is 0.5 m^2.

2. a) Derive an expression for the head loss (minor) when a horizontal pipe (of diameter d) suddenly expands to a pipe having a larger diameter D. Flow is steady and incompressible; flow rate Q is known. State all other assumptions clearly.

   b) A horizontal pipe has a sudden expansion from a diameter of 30 cm to a diameter of 60 cm. The hydraulic grade line rises by 2 cm due to the sudden expansion. Compute the flow rate and the minor loss coefficient.

3. a) A trapezoidal plate of parallel sides a and $2a$ and height h is immersed vertically in water with the side of length a horizontal and topmost. The top edge is at a depth h below the water surface. Determine the total force on one side of the plate and the location of the centre of pressure.

   b) What is the significance of Reynolds transport equation in Fluid Mechanics? Write the Reynolds transport equation for a stationary, non-deformable C.V. and briefly explain each term.

4. a) Define Vorticity and circulation.

   b) A 2-kg disk is constrained horizontally but is free to move vertically. The disk is struck from below by a vertical jet of water, as shown in Fig 1. The speed and diameter of the water jet are 10 m/s and 25 mm at the nozzle exit. Obtain a general expression for the speed of the water jet as a function of height, h. Find the height to which the disk will rise and remain stationary.

Contd... to p.2

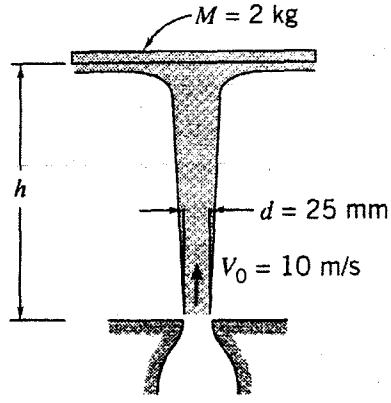

Fig. 1

5. a) An open tank, 6 m long, 4 m wide and 3 m deep, contains water upto a height of 2 m from bottom. Find the slope of the water surface and total thrust on the two 4 m × 3 m ends, if (i) the tank is driven with a uniform horizontal acceleration of 2.5 m/s^2 in the direction of its length, and (ii) the tank is driven vertically upward with an acceleration of 2.5 m/s^2.

   b) Define metacentre and metacentric height. How is the stability of a floating body affected by the position of the metacentre.

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Sub. : **Fluid Mechanics I**

Branch : Mechanical Engineering — Code No : **AM 305**

Time : 3 hrs. — Full marks : 70

(i) Answer any **six** questions taking **three** from **each half**
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Second Half

1. Define 'Geometric Similarity', 'Kinematic Similarity' and 'Dynamic Similarity' used in connection with Model study. What is 'Characteristic Length'?

   The terminal velocity of descent, V, of a hemispherical parachute is found to depend on the diameter, D, weight, W, acceleration due to gravity, g, density of air, ρ, and viscosity of air, μ. Obtain an expression for velocity, V, of the parachute by applying Buckingham's π-theorem.

2.a) An incompressible fluid flows through an elastic hose. The velocity of flow, u, and area of flow, A, at any instance of time, t, is given by,

$$u = u_o + a \cos \omega t \quad \text{and} \quad A = A_o + b \cos \omega t,$$

where, u_o , a , A_o , b , and ω are constants. Find an expression for average discharge per unit time through the hose.

b) A hollow sphere of radius r, completely filled with liquid, is rotated about its vertical axis at an angular speed of ω. Locate the line of maximum pressure with respect to the centre of the sphere.

3. A hemispherical tank of diameter 4 m contains water to a depth of 1.5 m. An orifice of diameter 50 mm and having $C_d = 0.6$ is provided at the bottom of the tank. Find the time required (i) for the water level to fall from 1.5 m to 1 m and (ii) for completely emptying the tank. Prove any formula you use for time of emptying the tank.

4. Deduce an expression for 'Rotation' of a fluid element in a two-dimensional flow field. Hence show that streamlines and equipotential lines always intersect at right angle, if they axist.

   The velocity components in X- and Y- directions in a two-dimensional flow field are given by $u = 2y / (x^2 + y^2)$ and $v = - 2x / (x^2 + y^2)$ respectively. Find stream function and velocity potential function, if they exist.

5. Water enters horizontally into a 150 mm × 100 mm, 60°-reducing bend fitted in a pipeline on vertical plane. The velocity and pressure at inlet to the bend are 1 m/sec and 300 kPa respectively. Vertical distance between outlet and inlet sections of the bend is 1 m and volume of the bend is 0.15 m^3. Neglecting effect of friction, determine magnitude and direction of the net force on the bend.