Department of Civil Engineering; Indian Institute of Technology Kharagpur
Mid-Autumn Semester Examination, 2010-'11; No. of Students: 67
Subject No.: **CE21003**
Subject: **Hydraulics**; Time: 2 Hrs; Full Marks: 30
Instructions: 1. Attempt all questions. Make suitable assumptions, wherever necessary.
2. *All notations used are standard* and $\gamma_{H,O} = 9.81$ kN/m^3.

Q1. Diagrammatically classify the fluids based on the linear/ non-linear relationship between shear stress and velocity gradient (i.e., shear strain) with/ without yield stress. [3]

Q2. Determine the new differential reading along the inclined leg of the mercury manometer of Figure 1, if the pressure in pipe A is decreased 12 kPa and the pressure in pipe B remains unchanged. The fluid in A has specific gravity of 0.9 and the fluid in B is water. [4]

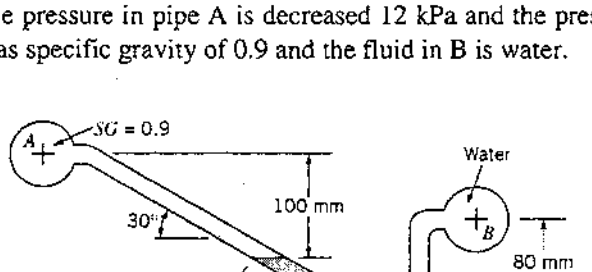


Figure 1

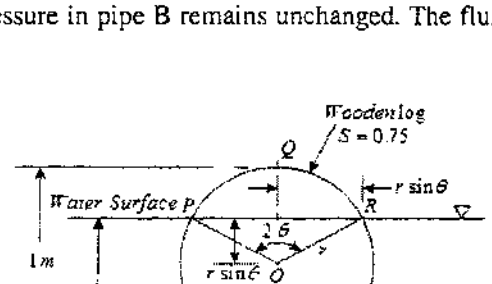
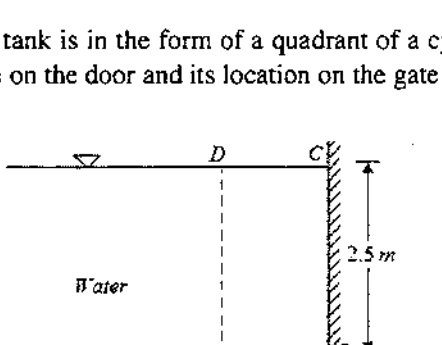


Figure 2

Q3. A log of wood 1 m in diameter and 8 m long is floating in river water. The specific gravity of log is 0.75. What is the depth (h) of the wooden log (Figure 2) in water? [3]

Q4. A door in a tank is in the form of a quadrant of a cylinder of 2 m radius and 2.2 m wide. Calculate the resultant force on the door and its location on the gate (Figure 3). [3]



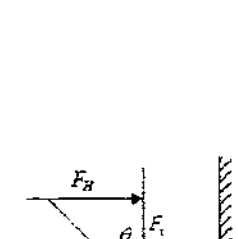


Figure 3

Q5. Find the local and convective acceleration as well as vorticity components at a point $(x, y, z) = (1, 2, 1)$ after 1 *sec* for the following flow field:

$$u = 2x^2 + 3y + 2t, \qquad v = -2xy + 3y^2 + 3zy + t, \qquad w = -\frac{3}{2}z^2 + 2xz - 9y^2z - 3t$$

Check whether the flow is irrotational. **[4]**

Q6. The flow of an incompressible fluid is defined by $u = 2$, $v = 8x$. Does a stream function exist? If so, find its expression. **[3]**

Q7. A 15 cm jet of water issues from a 1.5 m diameter tank. Assume that the velocity in the jet is $\sqrt{2gh}$ m/s where h is the elevation of the water surface above the outlet jet. How long will it take the water surface in the tank to drop from $h_0 = 2.5$ m to $h_f = 0.4$ m? **[4]**

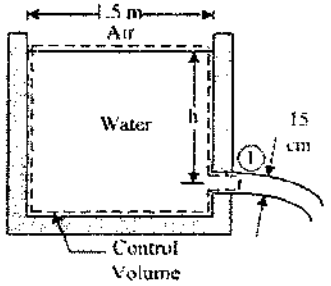


Figure 4

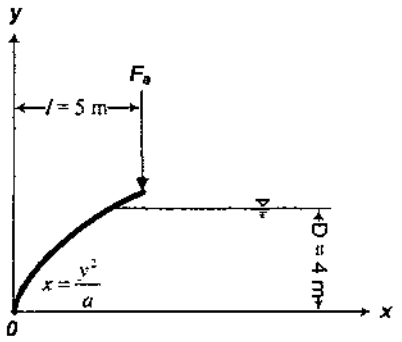


Figure 5

Q8. Fill in the blanks with appropriate word(s)/phrase: **[12 × ½ = 6]**

(a) Newton's law of viscosity relates _____ and _____.
(b) A control volume implies a/an _____ system.
(c) Streamline is a curve drawn _____ to the _____vector at every point.
(d) Streamline, pathline, and streakline are identical when the flow is _____.
(e) The material acceleration is zero for a _____.
(f) For natural equilibrium of floating bodies, the centre of gravity has to _____.
(g) The normal stress is the same in all directions at a point in a fluid when _____.
(h) The phenomenon of capillary rise or depression depends _____.
(i) Vorticity is Circulation _____.
(j) Vorticity about any axis is equal to _____the rotational component about that axis, for a rotating fluid element.

Q9. Bonus Question [*No part marking*]

The gate shown (Figure 5) is hinged at 0 and has constant width, w = 5 m. The equation of the surface is $x = y^2/a$, where a= 4 m. The depth of water to the right of the gate is D = 4 m. Find the magnitude of the force F_a, applied as shown, required to maintain the gate in equilibrium if the weight of the gate is neglected. **[10]**