BITS,Pilani-Dubai
International Academic City, Dubai
Second Semester 2007-2008
ME UC 212 Transport Phenomena I
Comprehensive Examination (Closed Book)

Max. Marks: 100 **Weightage: 40%** **Date: 01.06.08** **Duration: 3 Hours**

1. Answer all the questions
2. Assume suitable data if required
3. Draw sketches where necessary
4. Answer the questions sequentially

1.a. Define the terms: non-uniform flow and specific weight of fluid. **(2)**

b. A gate supporting water is shown in Fig 1. Find the height **h** of the water so that the gate tips about the hinge. Take the width of the gate as unity. **(8)**

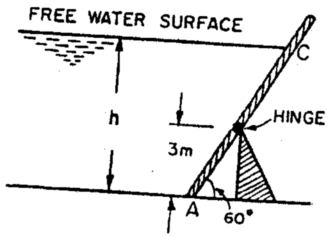


Fig -1

2. a.Draw the streamlines for the flow past a cylinder in the case of (i) $R_e<10$ and (ii) $R_e>10000$ **(2)**

b. Show that the stream lines and equipotential lines form a net of mutually perpendicular lines. **(8)**

3. A.Write the generalized x and y-momentum equations in differential form. **(2)**

b. A converging elbow as shown in Fig3. turns water through an angle of 135^0 in a vertical plane. The flow cross section diameter is 400 mm at the elbow inlet and 200 mm at outlet. The elbow flow passage volume is 0.2 m^3 between inlet and outlet. The water volume flow rate is 0.4 m^3/s and the elbow inlet and outlet pressures are 150 kPa and 90 kPa. The elbow mass is 12 kg. Calculate the horizontal and vertical forces required to hold the elbow in place. **(8)**

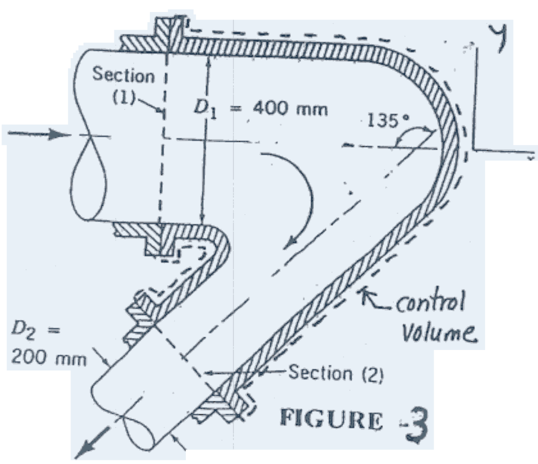


FIGURE -3

4 a. What do you understand by the term: vorticity (2)

b. A certain steady, incompressible, two-dimensional flow near a wall has the velocity component

$$u(x,y) = U\left(\frac{2y}{ax} - \frac{y^2}{a^2x^2}\right)$$

where a is constant. Find the velocity component v(x,y) assuming that v=0 at the wall, y=0. (8)

5. a. Write the Newton's law of viscosity. (2)

b. A solid cone of maximum radius R and vertex angle 2Θ is to rotate at angular velocity ω. An oil of viscosity μ and thickness t fills the gap between the cone and the housing. Derive an expression for the torque required and the rate of heat dissipation in the bearing. (8)

6. a. What are the assumptions made while deriving the Hagen-poiseulle equation? (2)

b. A viscous, incompressible, steady, laminar fluid flows upwards between the two vertical parallel plates. By use of Navier Stokes equation, find the expression for the pressure gradient in the direction of flow, in terms of mean velocity. (8)

7 a. Name the three similarities and their variables in model analysis. (2)

b. Using Buckingham л-theorem, show that the velocity through a circular orifice is given by

$$V = \sqrt{2gH}\phi\left[\frac{D}{H}, \frac{\mu}{\rho VH}\right]$$ where

H = head causing flow, d = diameter of the orifice, ρ = density

μ = viscosity of oil, g = acceleration due to gravity (8)

8. a. Is the flow within the boundary layer rotational or irrotational? Why? (2)

b. A plate 0.45 m x 0.15 m has been placed longitudinally in a crude oil (specific gravity 0.925 and kinematic viscosity of 0.9 x 10^{-4} m^2/s) which flows with velocity of 6 m/s. calculate the friction drag on the plate, thickness of the boundary layer at the tailing edge and shear stress at the trailing edge. (8)

9.a. Differentiate between the Eulerian and Lagrangian methods of representing fluid flow. (2)

b. A two-dimensional flow field is given by potential function, Φ = 3xy. Find i) the stream function , ii) the velocity at points A(2,6) and B(6,6) and the pressure difference between the points A and B and iii) the discharge between the stream lines passing through the points A and B. (8)

10. a. Define the terms: thermal resistance for conduction and convection (2)

b. A surface at 250^0 C exposed to the surroundings at 110^0 C convects and radiates heat to the surroundings. The convection coefficient and emissivity values are 75 W/m^2 ^{0}C and unity respectively. If the heat is conducted to the surface through a solid of conductivity 10 W/m^2 ^{0}C, what is the temperature gradient at the surface in the solid? (8)

BITS,Pilani - Dubai

Second Semester 2007 - 2008

Course: ME UC 212 Transport Phenomena I

TEST: 2[Open book]

Max.Marks 20
Weightage: 20%

Date:04.05.08

Time: 50 min

Note: (i) Answer all Questions
(ii) Assume suitable value if required

1. If viscous effects are neglected and the tank is large, determine the flow rate from the tank shown in Fig 1. Assume the specific gravity of oil is 0.81 and water is 1 respectively.

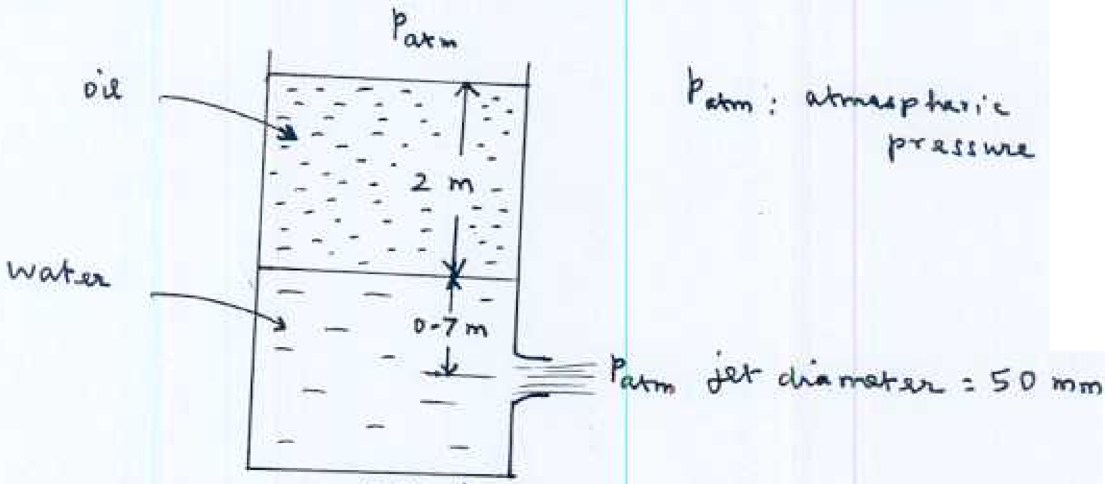
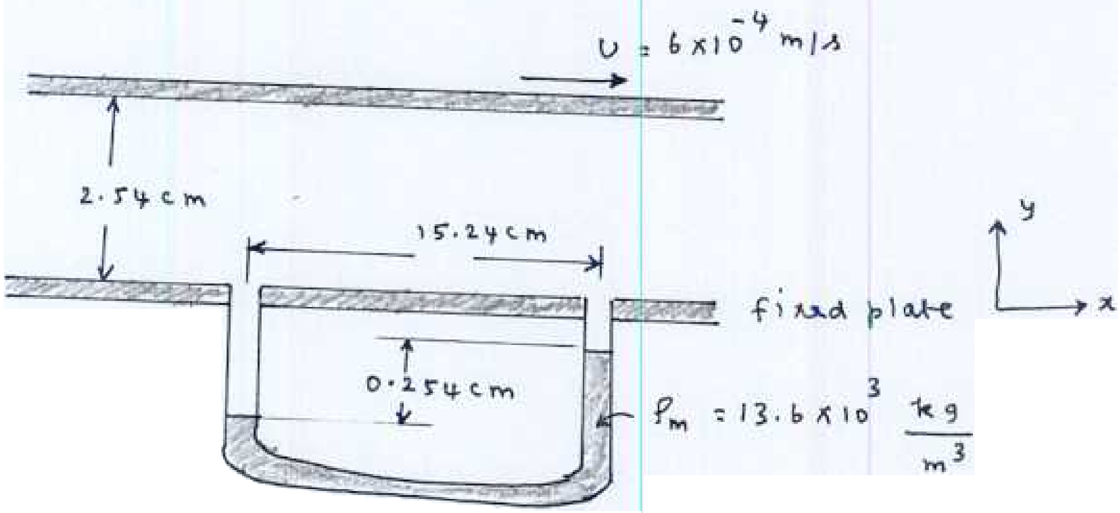


Fig. 1

2. A viscous fluid (specific weight 7848 N/m^3, viscosity=1.5 Ns/m^2) is contained between two horizontal parallel plates as shown in Fig 2. The fluid moves between the plates under the action of a pressure gradient and the upper plate moves with a velocity U while the bottom plate is fixed. The U- tube manometer connected between the two points along the bottom indicates the deferential reading of 0.254 cm. If the upper plate moves with a velocity of $6x10^{-4}$ m/s at what distance from the bottom plate does the maximum velocity in the gap between the two plates occur?

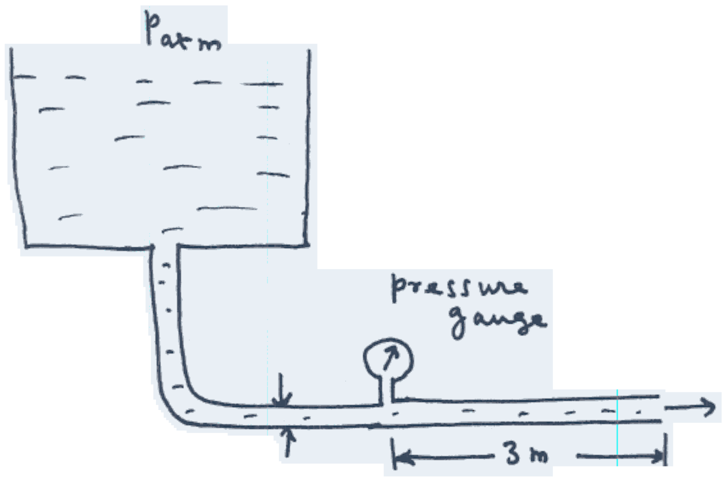


3.The two-dimensional velocity field for an incompressible, Newtonian fluid is given by

$$u = 12xy^2 - 6x^3 \quad \text{and} \quad v = 18x^2y - 4y^3$$

where the velocity has units of m/s when x and y are in meters. Determine the stresses σ_{xy}, σ_{yy} and τ_{xy} at the point x = 0.5 m, y = 1.0 m if the pressure at this point is 6 kPa and the fluid is having dynamic viscosity of 1.5 Ns/m^2 . Show these stresses on a sketch.

4. A simple flow system to be used for steady flow tests consists of a constant head tank is connected to a length of 4 mm diameter as shown in Fig 4. The liquid has viscosity of 0.015 Ns/m^2, a density of 1200 kg/m^3 and discharges into the atmosphere with a mean velocity of 2 m/s. (a)Verify the flow will be laminar (b) the flow is fully developed in the last 3 m of the tube. What is the pressure at the pressure gage? (c) What is the magnitude of the wall shearing stress in the fully developed region?



Dia = 4 mm

BITS,Pilani - Dubai
Second Semester 2007 - 2008
Course: ME UC 212 Transport Phenomena I
TEST: 1[Closed book]

Max.Marks :25
Weightage: 25 %

Date:23.03.08
Time: 50 min

Note: *(i) Answer all Questions*
(ii) Assume suitable value if required

1. The differential mercury manometer of shown in Fig1 is connected to pipe A containing gasoline (specific gravity =0.65) and the pipe B containing water. Determine the differential reading, h corresponding to pressure in A of 20 kPa and of vacuum of 150 mm Hg in B.
(6 marks)

Specific gravity of mercury = 13.6

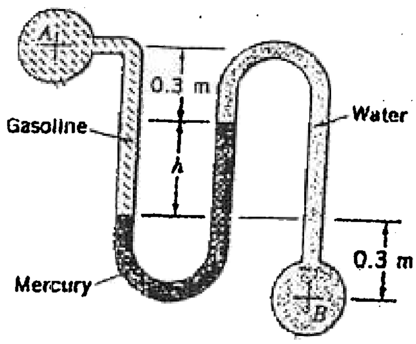


Fig. 1

2. A wooden beam with specific gravity of 0.6 and dimension 15 cm x 15 cm and 4 m long is hinged at A as shown in Fig 2. At what angle Θ will the beam float in the water?
(6 marks)

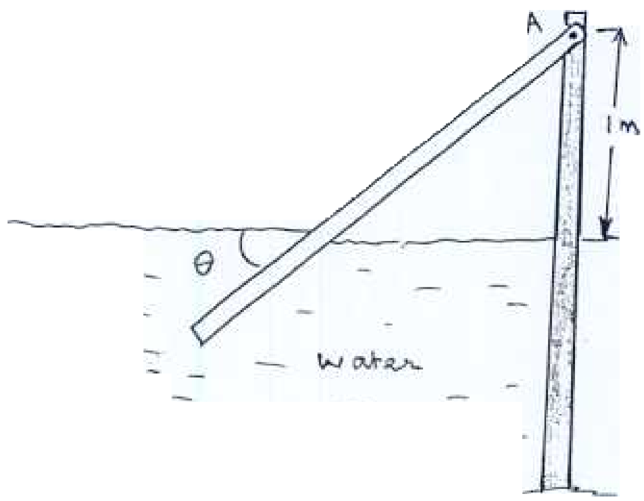


Fig. 2

3. Incompressible fluid flows steadily through a diverging channel as shown in Fig 3. At the inlet of height H, the flow is uniform with magnitude V_1. At the outlet, height 2H and velocity profile is

$$V_2 = V_m \cos(\frac{\pi y}{2H}) ,$$

where y is measured from channel centerline. Express V_m in terms of V_1.

(6 marks)

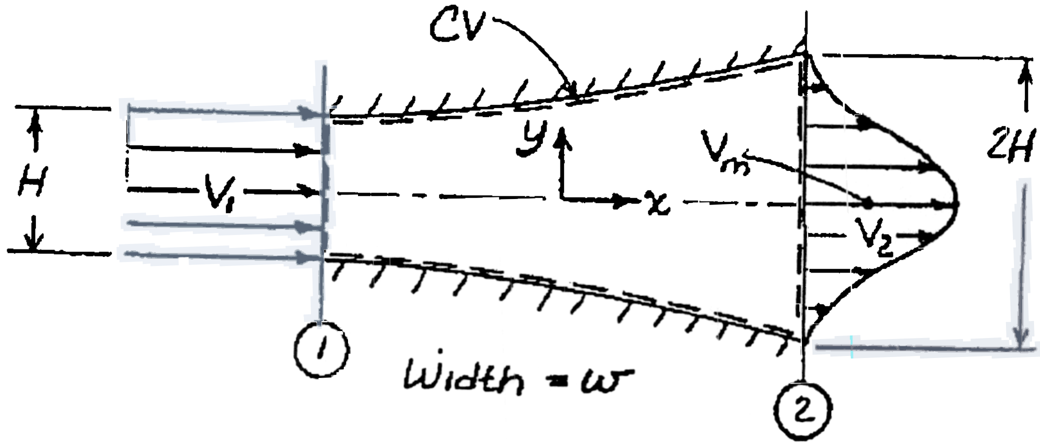


Fig. 3

4. A free jet of fluid strikes a wedge as shown in Fig 4. Of the total flow, a portion is deflected 30^0, the remainder is not deflected. The horizontal and vertical components of force needed to hold the wedge stationary are F_H and F_V respectively. Fluid velocity remains constant. Determine the force ratio F_H/F_V.

(7 marks)

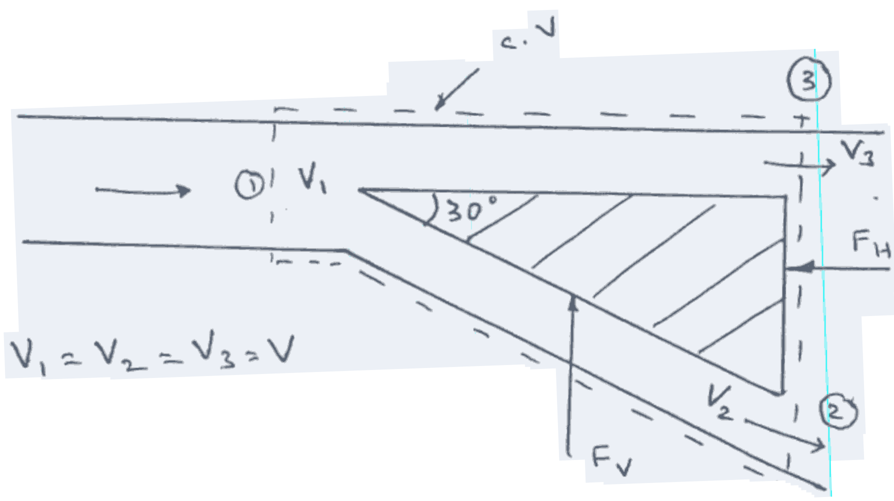


Fig. 4.