BITS, Pilani-Dubai
International Academic City, Dubai
Second Semester 2008-2009
ME C212/CHE C213 Transport Phenomena I/Fluid Flow Operations
Comprehensive Examination (Closed Book)

Max. Marks: 80 **Weightage: 40%** **Date: 01.06.08** **Duration: 3 Hours**

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

1. (a) Differentiate between real fluids and ideal fluids (2M)

(b) Two large fixed parallel plates are 12 mm apart. The space between the plates is filled with oil of viscosity 0.972 Ns/m^2. A flat thin plate 0.25 m^2 area moves through the oil at a velocity of 0.3 m/s. Calculate the shear force:
(i) when the thin plate is equidistant from both plates, and
(ii) when the thin plate is at a distance of 4 mm from one of the plate surfaces (8M)

2 (a) Define the terms : centre of pressure and total pressure (2M)

(b) In Fig 2, pipe A contains a liquid with specific gravity of 0.7 and pipe B contains specific gravity of 0.9 and manometer fluid is mercury with density 13600 kg/m^3. Determine the new differential reading if the pressure in pipe A is decreased 25 kPa and the pressure in pipe B remains constant. The initial differential reading is 0.30 m. (8M)

3.(a) Differentiate between pitot tube and orifice meter. (2M)

(b) Two water jets of equal size with 10 cm diameter and equal speed with 10 m/s strike each other as shown in Fig 3. Determine the speed v and direction θ of the resulting combined jet. Neglecting pressure, viscous and gravitational forces. (8M)

4(a) What are the conditions for flow to be irrotational ? (2M)

(b) The stream function for a two-dimensional flow is given by Ψ = 2xy. Calculate the velocity at the point P(2,3). Also find the potential function, Φ. (8M)

5(a) State the assumptions to derive the Bernoulli's theorem. (2M)

(b) Water flows steadily up the vertical 0.1 m diameter pipe and the nozzle, which is 0.05 m in diameter, discharging to atmospheric pressure as shown in Fig 5. The stream velocity at the nozzle exit must be 20 m/s. Calculate the minimum gage pressure required at section 1. If the device is inverted what pressure would be the required at section 1 to maintain the nozzle exit velocity at 20 m/s? (8M)

6(a) How do you select the repeating variables? (2M)

(b) Using Buckingham π-theorem, show that the discharge q consumed by an oil rig is given by

$$Q = Nd^3 \phi\left[\frac{\mu}{\rho N d^2}, \frac{\sigma}{\rho N^2 d^3}, \frac{S}{\rho N^2 d}\right] \text{ where}$$

N = rotational speed d = internal diameter of rig ρ = density μ = viscosity of oil σ = surface tension S = specific weight of oil. (8M)

7(a) State the important characteristics of laminar and turbulent flows. (2M)

(b) Laminar flow is taking place in a pipe of diameter of 200 mm. The maximum velocity is 1.5 m/s. Find the mean velocity and radius at which this occurs. Also calculate the velocity at 4 cm from the wall of the pipe. (8M)

8(a) Define the terms: pressure drag and viscous drag (2M)

(b) The velocity profile for laminar boundary layer $\frac{u}{U} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$.

The wall shear stress is $\tau_w = \rho U^2 \frac{d\theta}{dx}$ where θ is momentum thickness. Find boundary layer thickness δ in terms of Reynolds number. (8M)

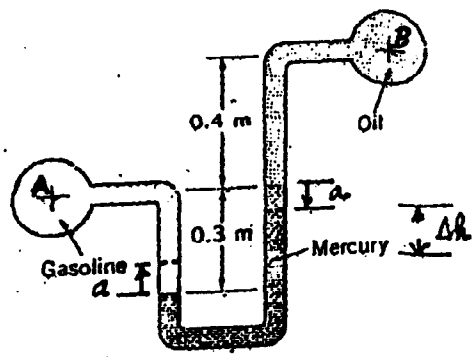

Fig 2.

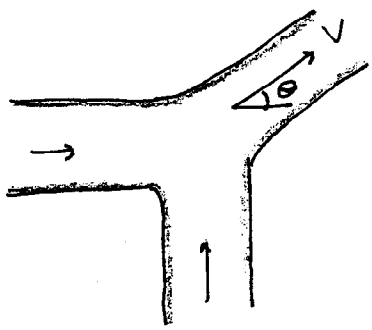

Fig 3.

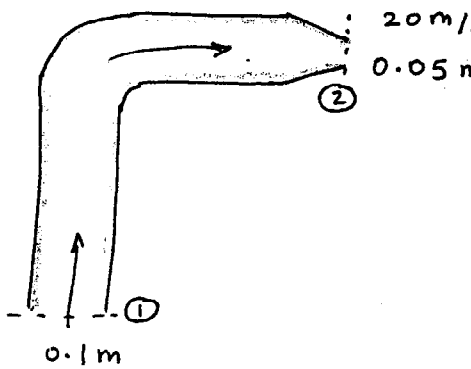

Fig 5

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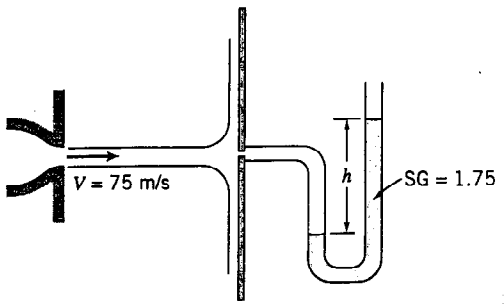
TEST: 2[Open book]

Max.Marks :20 **Date:12.04.2009**

Weightage: 20 % **Time: 50 min**

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

1. A horizontal jet of air (density is constant and is equal to 1.23 kg/m^3) with 10 mm diameter strikes a stationary vertical disk of 200 mm diameter. The jet velocity is 75 m/s at the nozzle exit. A manometer is connected to the center of the disk as shown in figure. Calculate (i) the manometer fluid level difference, h if the specific gravity of manometer fluid is 1.75 and (ii) the force exerted by the jet on the disk **(5)**

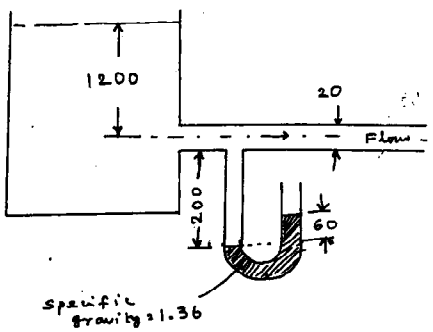


2..The two-dimensional velocity field for an incompressible, Newtonian fluid is given by

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

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. (5)

3. Water flows from a large tank through a 20 mm diameter pipe. One end of a U-tube manometer is connected to the pipe and other end is open as shown in figure. Calculate the velocity in the pipe and the rate of discharge from the tank. **(5)**



All dimensions in mm

4.The velocity distribution in a pipe is given by

$\frac{u}{u_{max}} = 1 - \left(\frac{r}{R}\right)^n$. Obtain (i) an expression for mean velocity in terms of u_{max} and n and (ii) frictional force at pipe wall for a distance of 2R and viscosity μ. **(5)**

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Course: ME C 212/CHE C213 Transport Phenomena I /Fluid Flow Operations

TEST: 1[Closed book]

Max.Marks :25 **Date:01.03.2009**

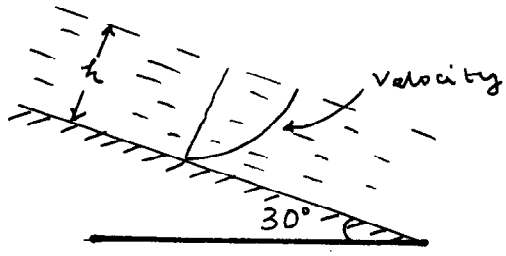
Weightage: 25 % **Time: 50 min**

Note: ***(i) Answer all Questions***

(ii) Assume suitable value if required

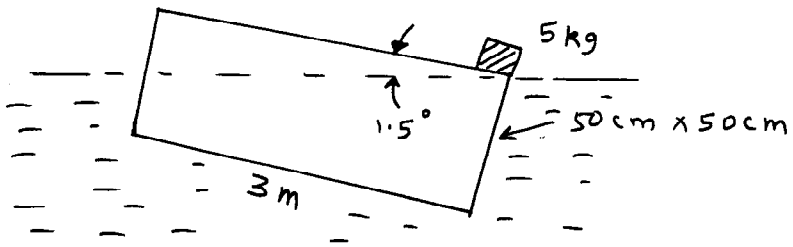
1.An oil with specific gravity of 0.85 and viscosity of 1.12×10^{-3} Ns/m^2 flows steadily down a surface inclined $\Theta = 30^0$ as shown in Fig. 1. The value of h = 0.1mm and velocity profile is given by (5 marks)

$$u = \frac{\rho g}{\mu}(hy - \frac{y^2}{2}) \sin \Theta$$

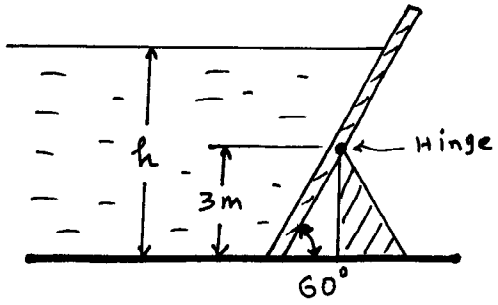


Determine i) the magnitude and direction of the shear stress that acts on the surface and ii) shear force on a 5000 mm^2 section of the plate and its direction.

2. When a 5 kg mass is placed on the end of a floating 50 cm x 50 cm x 3 m wooden beam tilts at 1.5^0 with its right upper corner at the surface as shown in Fig2. What is the specific weight of the wood? (5 marks)

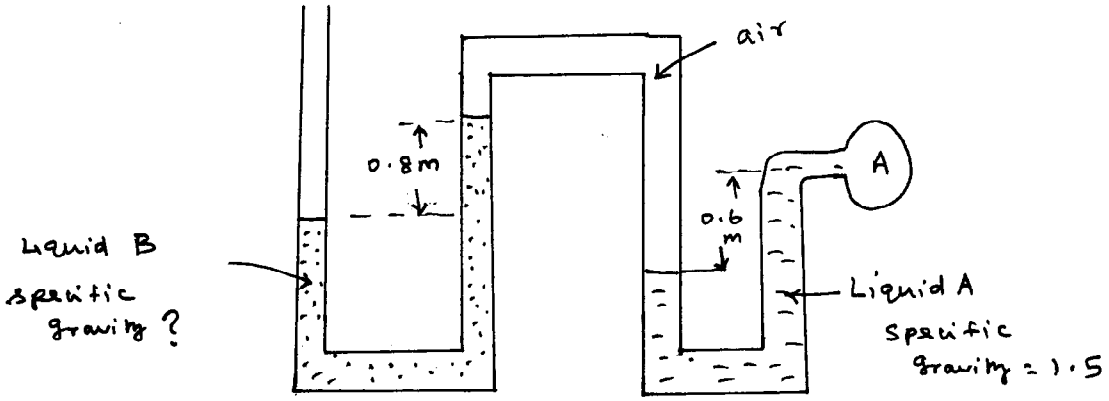


3. A gate supporting water is shown in Fig 3. Find the height **h** of the water so that the gate tips about the hinge. Take the width of the gate as unity. (5 marks)



(PTO)

4. For the Fig 4 shown, find the specific gravity of liquid B, if the pressure at A is -18 kN/m^2. (5 marks)



5.a) Draw the velocity profiles for (i) viscous flow in pipe and (ii) inviscid flow in pipe. Justify your answer (2 marks)

b) Write the expression for rate of shearing strain for two-dimensional flow (1 mark)

c) How will you calculate the surface tension for liquid jet ? (2 marks)

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Quiz -3

Weightage 5 % **Total Marks: 10**

Name : ---------- ID No:----------

Small droplets of liquid are formed when a liquid jet breaks up in spray and fuel injection process. The resulting droplet diameter is thought to depend on liquid density and viscosity and surface tension as well as jet velocity V and diameter D. How many dimensionless numbers are required to characterize the process? Determine these numbers.

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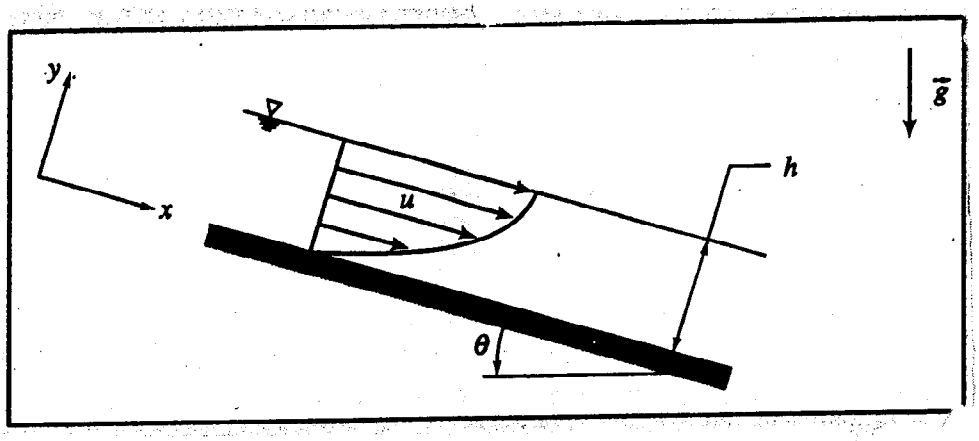
Quiz -2

Weightage 5 % , Time : 20 min **Total Marks : 10**

Name : **ID No:**

Find the velocity profile and volume flow rate for a liquid flow down an inclined plane in a steady film thickness h as shown in figure.



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Quiz -1

Weightage 5 % **Total Marks - 10**

Name : **ID No:**

1.The hydrostatic law states that the rate of increase of pressure in a vertical direction is equal to

a) density of fluid b) specific weight of fluid c) weight of the fluid d) none of the above

2.Fluid statics deals with

b) A) viscous and pressure forces b) viscous and gravity forces c) gravity and pressure forces d) surface tension and gravity forces

3. Atmospheric pressure in terms of water column is ----------

4. The pressure intensity at a point in the flow field is given 3.924 N/cm2. Find the corresponding height of fluid for of oil of specific gravity 0.9.

a) 4.49 m of oil b) 0.9 m of oil c) 4.44 m of oil d)non of the above

5.A pipe contains an oil of specific gravity 0.9. A differential manometer is connected at the points A and B shows a difference in mercury level as 15 cm. Find the difference in pressure at two points.

6.A mass of 3 Kg is placed on a planet with acceleration of gravity of 0.5 m/s^2. What is its mass in kilogram ?

7.Surface tension is caused by the force of ----------at the free surface and its unit is ----------.

8.The point of application of the total pressure on the surface is called ----------

9.Unit for kinematic viscosity is ---------- and kinematic viscosity is ----------

10.For the container shown in Fig, the atmospheric pressure is 101.33kPa and the pressure at the bottom of the tank is 237 kPa, what is the specific gravity of fluid X.