BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
SECOND SEMESTER 2005 – 2006
ME UC212 TRANSPORT PHENOMENA – 1
COMPREHENSIVE EXAMINATION DURATION: 180 MINUTES
MAXIMUM MARKS: 40 WEIGHTAGE: 40%

NOTES:

1. Highlight all your answers by enclosing in boxes.
2. Assume any missing data suitably and mention the same at appropriate place in your answer.
3. All the parts of a particular question should be answered together.

1. A cylindrical gate of diameter 2.5m retains two liquids on either side as shown in Figure1. When the local acceleration due to gravity is 9.79 m/s^2 estimate the following for unit length in z – direction.
   (a) Horizontal force acting on the gate due oil of specific gravity 0.9
   (b) Horizontal force acting on the gate due oil of specific gravity 0.8.
   (c) Vertical force acting on the gate due oil of specific gravity 0.9
   (d) Vertical force acting on the gate due oil of specific gravity 0.8.
   (e) The net horizontal and vertical forces acting on the gate.
   (f) Resultant force and angle of application of resultant force.

   [7M]

2. (a) Refer Figure 2. A fluid jet at 1 strikes a plate containing a hole. Part of jet passes through the hole and the remaining jet gets deflected in the direction indicated by 2 and 4. Starting from the basic equation for momentum transfer, obtain an expression for horizontal force required to hold the plate as a function of densities, areas, velocities at 1, 2, 3, 4.
   (b) If velocities at 1 and 3 are 25m/s; diameters at 1 and 3 are 6 cm and 4 cm respectively; the fluid is water; the flows are steady and incompressible, calculate the magnitude of the force required to hold the plate.

   [6M]

3. Refer Figure 3 which shows, a 10 cm fire hose with a 3 cm nozzle discharging 1.5m^3/min of water to the atmosphere. Considering the flow to be steady and incompressible answer the following.
   (a) Simplify the continuity equation and hence get the values of velocities at 1 and 2.
   (b) Simplify the applicable Bernoulli's equation to get the relationship between pressures and velocities at 1 and 2. Hence find the magnitude of gauge pressure at 1.
   (c) Simplify the applicable momentum equation and get the magnitude of force exerted by the flange bolts to hold the nozzle on the hose.

   [7M]

4. Two co axial cylinders 10cm and 9.75 cm in diameter and 2.5 cm high have both their ends open and have viscous liquid filled in between. A torque of 1.2 N – m is produced when the outer one is rotating at 90rpm. Determine
   (a) Applicable velocity gradient
   (b) Expression for shear stress and shear force in terms of dynamic viscosity of liquid
   (c) Coefficient of viscosity of the liquid. **[6M]**

5. Discharge, Q across a triangular notch is a function of variables namely, density, ρ; Head, H; Acceleration due to gravity, g; dynamic viscosity, μ; surface tension, σ; and notch angle, α. Using the dimensional analysis show that $Q = C * H^{5/2}$ where C is a constant. **[7M]**

6. Starting from the first principles derive the 3 – dimensional generalized heat conduction equation in Cartesian coordinates. Simplify the so derived conduction equation for one dimensional steady heat transfer. **[7M]**

Figure 1

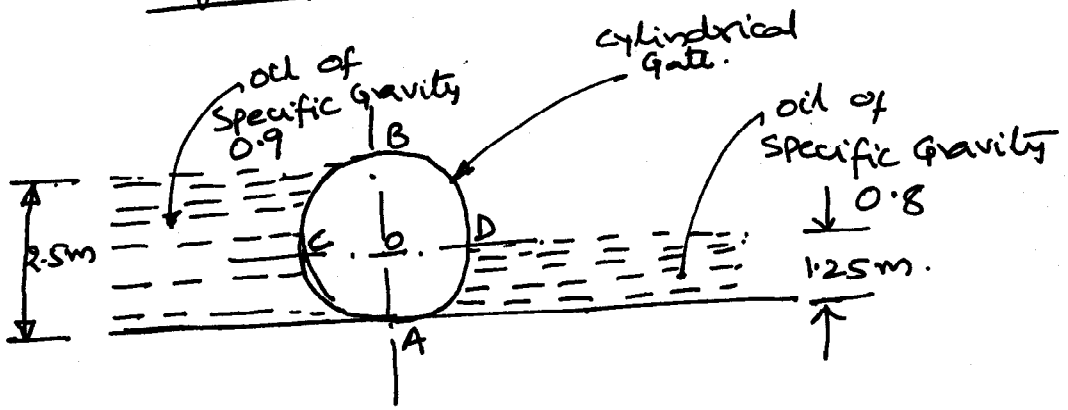


Figure 2

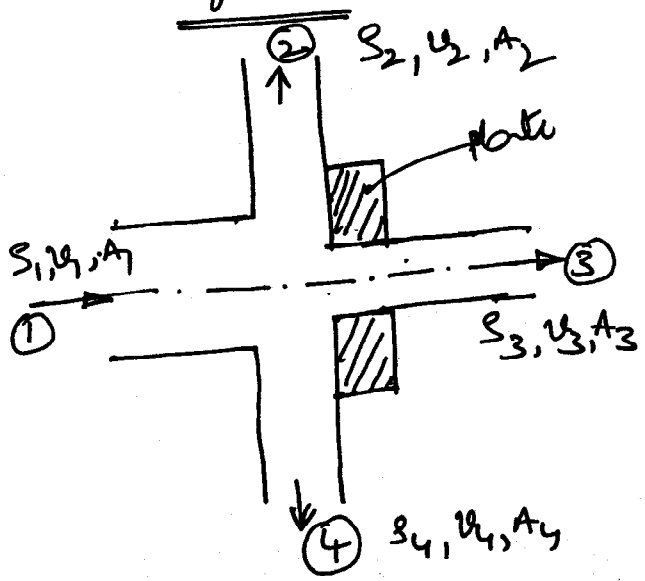
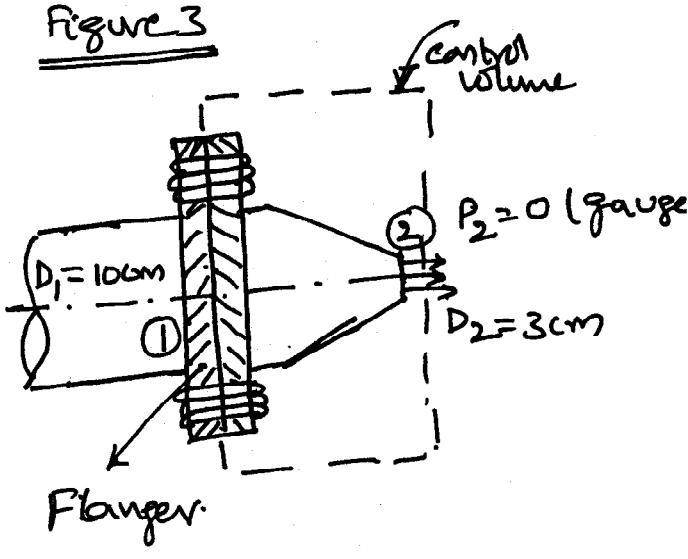


Figure 3



BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
SECOND SEMESTER 2005 – 2006
ME UC212 TRANSPORT PHENOMENA – 1
TEST 2 (OPEN BOOK) Date: 07/04/06 DURATION: 50 MINUTES
MAXIMUM MARKS: 20 WEIGHTAGE: 20%

NOTES:

1. Highlight all your answers by enclosing in boxes.
2. Assume any missing data suitably and mention the same at appropriate place in your answer.
3. All the parts of a particular question should be answered together.

1. Oil of specific gravity 0.8 flows smoothly through the circular reducing section shown in Figure Q1. The volumetric flow rate of oil is 0.08 m^3/s. Pressures at entry and exit are 350kPa and 35 kPa respectively. Diameters at the entry and exit are 0.3m and 0.06m respectively. The flow can be considered as steady and incompressible.
   (a) Calculate Velocities at the inlet and exit
   (b) Simplify the applicable momentum equation and hence find the force which must be applied to the reducer to hold in place.

   [8M]

2. The venture meter shown in figure reduces the pipe diameter from 10 cm at 1 to a 5 cm at 2. A manometer with mercury as manometric fluid connected between sections 1 and 2 indicates a reading of 1.2m. The flow through the venturimeter can be assumed to be steady, incompressible, irrotational and inviscid.

   (a) Using continuity equation, get the relationship between velocities at 2 and 1.

   (b) Balance the pressures at "a" and "b" and get the value of $\frac{P_1 - P_2}{\rho g}$ in meters.

   (c) Using applicable form of energy equation, calculate the value of velocity at 1 and hence calculate discharge through the pipe.

   [8M]

3. Fluid flows between two parallel plates, a distance "h" apart. The upper plate moves at a velocity of v_o. The lower plate is stationery. The velocity profile is given by the equation $v_x = \frac{1}{2\mu}\frac{dp}{dx}y^2 + C_1 y + C_2$. Using the appropriate boundary conditions find the values/expressions for C_1 and C_2 and hence show that the velocity profile is a parabolic velocity profile. **[4M]**

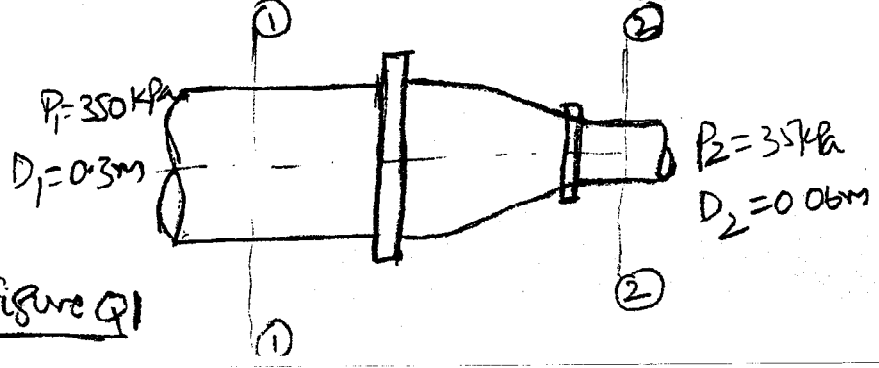


Figure Q1

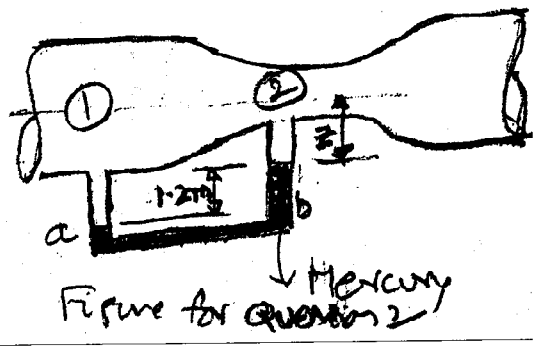


Figure for Question 2

BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
SECOND SEMESTER 2005 – 2006
ME UC212 TRANSPORT PHENOMENA – 1
TEST 1 (CLOSED BOOK) Date: 19/03/06 DURATION: 50 MINUTES
MAXIMUM MARKS: 20 WEIGHTAGE: 20%

NOTES:

1. Highlight all your answers by enclosing in boxes.
2. Assume any missing data suitably and mention the same at appropriate place in your answer.
3. All the parts of a particular question should be answered together.

1. The tank in Figure Q1 is closed at top and contains air at a pressure P_A. Calculate the value of P_A for the manometer reading shown, when the set up is at a place where the acceleration due to gravity is 9.79m/s^2. **[4M]**

2. Refer Figure Q2. The lower corner of a water tank has the shape of a quadrant of a circle of radius 1.2m. The water tank is 3m long in z – direction. Find the magnitudes of horizontal force; vertical force; and resultant force acting on the curved surface. Also find the angle of application of this resultant force. **[8M]**

3. Carbon dioxide is passing through a 80mm diameter pipe. The inlet conditions are velocity 6m/s; pressure 200kN/m^2; and temperature is 20°C. Exit conditions are pressure 120kN/m^2; and temperature is 30°C. Atmospheric pressure is 1.03 bar and the gas can be considered as Ideal gas with gas constant as 189J/kgK. Assuming the flow to be steady and incompressible find mass flow rate and exit velocity after simplifying the continuity equation. **[8M]**

Figure Q1

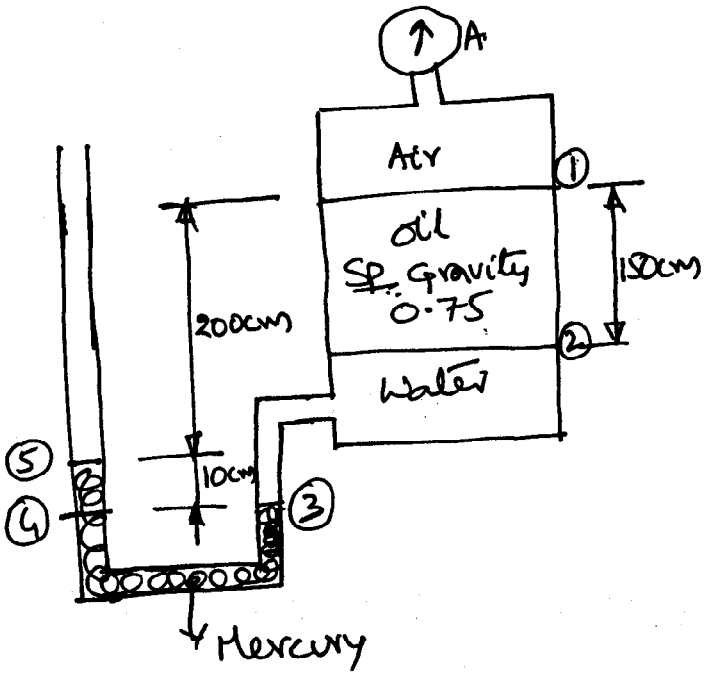


Figure Q2