BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI

SECOND SEMESTER 2007-2008

CHE UC213 Fluid Flow Operations

Second Year Chemical Engineering

Comprehensive Examination

(Closed Book)

21.05.08

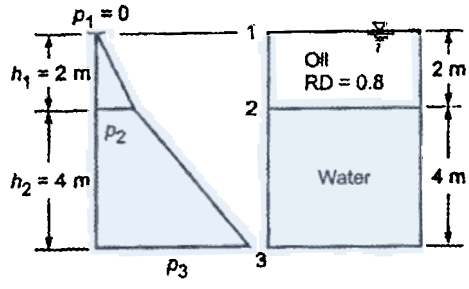
DURATION: 3 Hours **MAXIMUM MARKS: 120**

Note: Attempt ALL questions. Mention appropriate units in your answers. Without units, the answer will not be deemed as correct, even if the numerical value is correct.

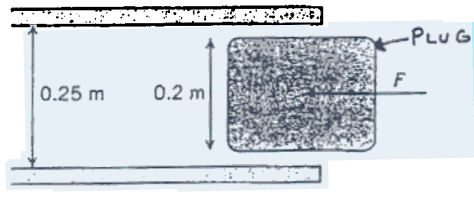
1 a) The mass of the golf ball is 45.9 g and its mean diameter is 41 mm. Determine the density and specific gravity of the golf ball. (2 marks)

b) Sketch shear stress and apparent viscosity as a function of deformation rate for one dimensional flow of various non-Newtonian fluids and discuss each term briefly. (8 marks)

c) A 6 m deep tank contains 4m of water and 2m of oil of relative density 0.8. Determine the pressure at bottom of the tank. (5 marks)

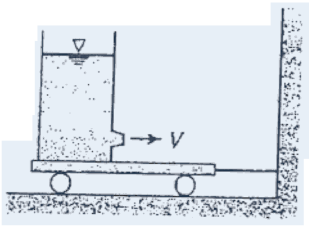


2 a) Find the force required to hold the plug in place at the exit of the water pipe. The flow rate is $1.5 m^3/s$, and the upstream pressure is 3.5MPa. (12 marks)



b) A large tank of height h = 1 m diameter d = 0.6m is affixed to a cart as shown. Water issues from the tank is approximately $V = \sqrt{(2hy)}$ where y is the height from the nozzle to the free surface. Determine the tension in the wire when y = 0.8 m.

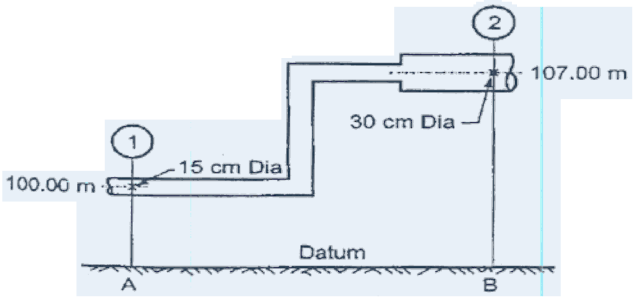
(8 marks)



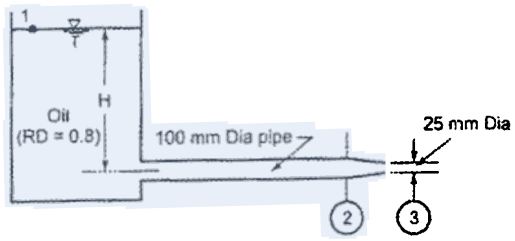
3 a) Consider the velocity field given by $\vec{V} = A(x^2 + 2xy)\hat{i} - A(2xy + y^2)\hat{j}$ in the xy plane, where A = 0.25 $m^{-1}.s^{-1}$, and the coordinates are measured in meters. Is this a possible incompressible flow field? Calculate the acceleration of a fluid particle at point (x,y) = (2,1). (10 marks)

b) As an aircraft flies through a cold front, an on-board instrument indicates that ambient temperature drops at the rate of 0.5°F per minute. Other instrument shows an air speed of 155 m/s and a 17 m/sec rate of climb. The front is stationary and vertically uniform. Calculate the rate of change of temperature with respect to horizontal distance through the cold front. (10 marks)

4. a) A pipeline is 15cm in diameter and is at an elevation of 100 m at section A. At section B it is at an elevation of 107 m and has a diameter of 30 cm. When a discharge of 50L/s of water is passed through this pipe the pressure at section A is observed to be 30KPa. The energy loss in the pipe is 2m. Calculate the pressure from B to A. (8 marks)



b) Figure shows a nozzle at the end of a pipe discharging oil from a tank to atmosphere. Estimate the discharge from the nozzle when the head H in the tank is 4 m. The loss in the pipe can be taken as 20 $V^2/2g$, where V = velocity in the pipe. The loss of energy in the nozzle can be assumed to be zero. Also determine the pressure at the section 2 12 marks)



5 a) Small droplets of liquid are formed when a liquid jet breaks up in spray and fuel injection processes. The resulting droplet diameter, d, is thought to depend on liquid density, viscosity and surface tension, as well as jet speed, V, and diameter, D. How many dimensionless ratios are required to characterize this process? Determine these ratios. 10 marks)

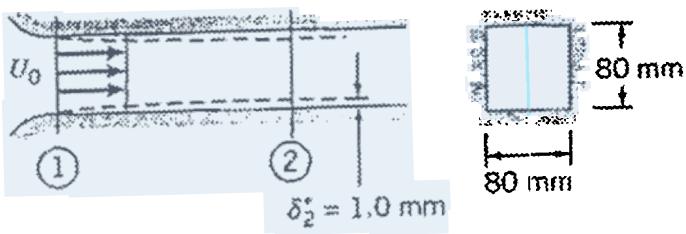
b) Water flows steadily in a horizontal 125 mm diameter smooth pipe. The pipe is 150 m long and the pressure drop between the two ends is 150kPa. Find the volume flow rate through the pipe. (15 marks)

Data Given:
density of fluid = 999 kg/m^3, kinematic viscosity of water = 14×10^{-6} m^2/s

Friction factor correlations

Laminar flow = 64/Re, Turbulent flow, smooth pipes $\frac{1}{\sqrt{f}} = 8\log\left(\frac{Re}{7}\right)$

6 a) Air flow in the entrance region of a square duct, as shown. The velocity is uniform, U_o = 30m/s, and the duct is 80mm square. At a section 0.3 m downstream from the entrance, the displacement thickness, δ*, on each wall measures 1 mm. Determine the pressure change between sections and 2. (10 marks)



b) Define and distinguish the terms mixing and agitation. (4 marks)

c) Mention the types of the impellers for low to high viscosity liquids and discuss in brief with neat sketch. (6 marks)

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SECOND SEMESTER 2007-2008

CHE UC213 Fluid Flow Operations

Second Year Chemical Engineering

Test - 2

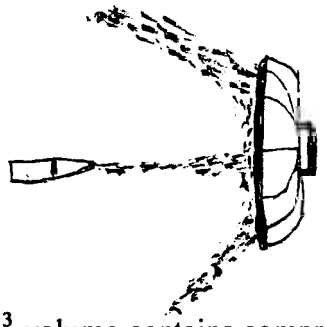
(Open Book)

20.04.08

DURATION: 50 MINUTES **MAXIMUM MARKS: 60**

Note: Attempt ALL questions. Mention appropriate units in your answers. Without units, the answer will not be deemed as correct, even if the numerical value is correct. **Only Prescribed Text book and hand written Notes are allowed**

1 The police are using fire hoses to disperse an unruly crowd. The fire hoses deliver 0.01 m^3/s of water at a velocity of 30 m/s. A member of the crowd has picked up a garbage can lid and using it as a shield to deflect the flow. He turns the lid around so that he can hold it by the handle. However, because of the shape of the lid the flow goes off as show in figure with an average x component of the velocity of -15m/s.What force must he exert? (8 marks)



2 A tank of 0.5 m^3 volume contains compressed air. A valve is opened and air escapes with a velocity of 300 m/s through an opening of 130 mm^2 area. Air temperature passing through the opening is -15°C and the absolute pressure is 350 Kpa. Find the rate of density of the air in the tank at this moment. (15 marks)

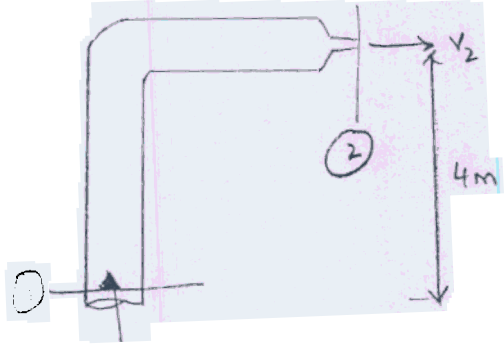
3 The velocity field within a laminar boundary layer is approximated by the expression

$$\vec{V} = \frac{AUy}{x^{1/2}}\hat{i} + \frac{AUy^2}{4x^{3/2}}\hat{j}$$

In this expression, A = 141 $m^{-1/2}$, and U = 0.240 m/s is the free stream velocity. Show that this velocity field represents a possible incompressible flow. Calculate the acceleration of a fluid particle at point (x, y) = (0.5m, 5mm). Determine the slope of the stream line through the point. (15 marks)

4. An incompressible liquid with negligible viscosity flows steadily through a horizontal at a constant diameter. In a porous section of length L = 0.3 m, liquid is removed at a constant rate per unit length. So the uniform axial velocity in the pipe is u(x) = U(1-x/2L), where U = 5 m/s. Develop an expression for the acceleration of a fluid particle along the center line of the porous section. (7 marks)

5. Water flows steadily up the vertical 0.1 m diameter pipe and out the nozzle, which is 0.05 m in diameter, discharging to atmospheric pressure. The stream velocity at the nozzle exit must be 20 m/s. If the device were inverted, what would be the required minimum pressure at section 1 to maintain the nozzle exit velocity at 20m/s? (15 marks)



BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI

SECOND SEMESTER 2007-2008

CHE UC231 Fluid Flow Operations

Test - 1

(Closed Book)

SECOND YEAR

02.03.08

DURATION: 50 MINUTES **MAXIMUM MARKS: 60**

Note: Attempt ALL questions. Mention appropriate units in your answers. Without units, the answer will not be deemed as correct, even if the numerical value is correct.

The barrel of a bicycle tire pump becomes quite warm during use. Explain the mechanisms responsible for the temperature increase. (6 marks)

2 An unknown immiscible liquid seep into the bottom of an open oil tank. Some measurements indicate that the depth of the unknown liquid is 1.5 m and the depth of the oil (specific weight = 8.5 kN/m^3) floating on top is 5.0 m. A pressure gauge connected to the bottom of the tank reads 65 kPa. What is the specific gravity of the unknown liquid? (6 marks)

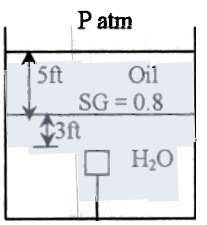
For the velocity fields given below, determine whether the flow is one, two or three dimensional and the flow is steady or unsteady flow. (6 marks)

(i) $\vec{V} = axy\hat{i} - byzt\hat{j}$ (ii) $\vec{V} = \left(ae^{-bx}\right)\hat{i} - bx^2\hat{j}$

(iii) $\vec{V} = ax\hat{i} - by\hat{j}$

4 Define the terms: (a) Timelines (b) pathlines (c) streaklines (2 × 3 = 6 marks)

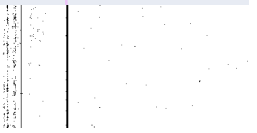
5 A 1 ft cube of solid oak (SG = 0.77) is held by a tether as shown. Calculate the actual force of the water on the bottom surface of the cube and the tension in the tether. (15 marks)



6 For an atmospheric pressure of 101 KPa (abs) determine the heights of the fluid columns in barometers containing one of the following liquids: (a) mercury (b) water and (c) ethyl alcohol. Calculate the heights including the effects of vapor pressure and compare the results with those obtained neglecting vapor pressure. Give comments on your results. (15 marks)

Data:

Vapor pressure of mercury is 1.6×10^{-1} N/m^2
Vapor pressure of water is 1.77×10^{3} N/m^2
Vapor pressure of ethyl alcohol is 5.9×10^{3} N/m^2



7 The water level in an open standpipe is 75 ft above the ground. What is the static pressure at a fire hydrant that is connected to the stand pipe and located at ground level? Express you answer in KPa. (6 marks)