THE OPEN UNIVERSITY OF SRI LANKA
Department of Civil Engineering
Diploma in Technology - Level 3
Diploma in Industrial Studies – Level 3

CEX 3232 - HYDRAULICS AND HYDROLOGY

FINAL EXAMINATION 2011/12

Time Allowed : Three Hours

Date : 12th March, 2012 Time : 0930 - 1230

ANSWER **ALL THREE** QUESTIONS IN **PART A AND ANY TWO** QUESTIONS IN **PART B**. ALL QUESTIONS CARRY EQUAL MARKS.

PART A

Answer **all three** questions

1) Water flows from a large tank, X, to the atmosphere, through a pipeline ABCDE, as shown in Figure 1. The elevations of the nodes and lengths of the pipes are shown in the figure. All the pipes have a diameter of 25 mm . Neglect all energy losses.

a) Sketch, on graphs placed one above the other, the variation of the Elevation Head, Velocity Head, Pressure Head and Total Head from O, a point on the free surface of Tank X, to E. Identify your datum for the elevation.

b) Calculate the discharge through the pipeline. State all your assumptions.

c) Calculate the lowest pressure in the pipeline.

d) What would happen to

(i) the discharge from the tank

(ii) the lowest pressure in the pipeline

if the section DE of the pipeline was removed and the water discharged to the atmosphere at D? Explain your answer.

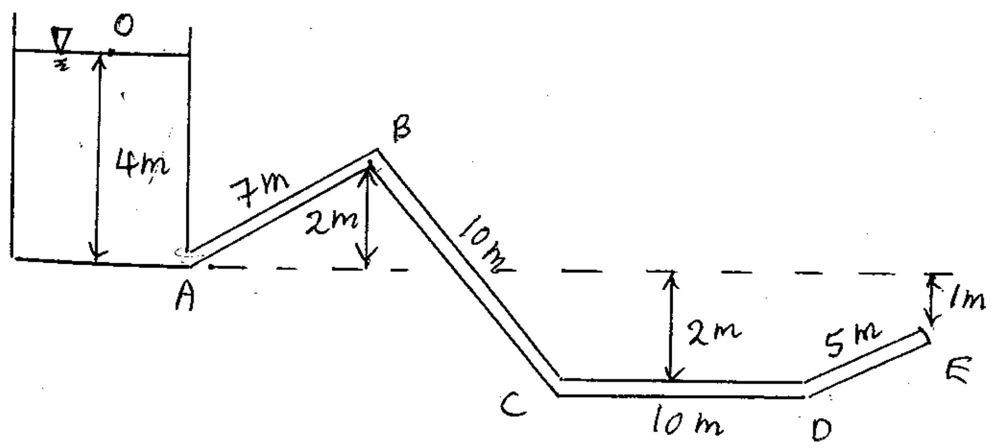

Figure 1

②

2) Water flows steadily in a horizontal pipe section AB as shown in Figure 2. The diameter of the pipe decreases from 5 cm at A to 2 cm at B, as shown in the figure. The average velocity of the flow at A is 0.2 m/s. A simple water manometer connected to the pipe at A shows a water level of 15 cm above the level of A, as shown in the figure. The density of water is 1000 kg/m^3.

a) Calculate the flux of energy at A. Explain your answer.

b) Calculate the pressure head at B. Assume that there are no energy losses between A and B.

c) Calculate the magnitude and direction of the force on the pipe section AB due to the flow of water.

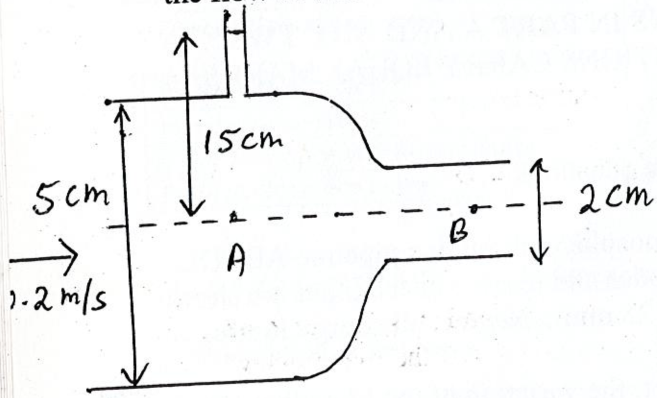

Figure 2

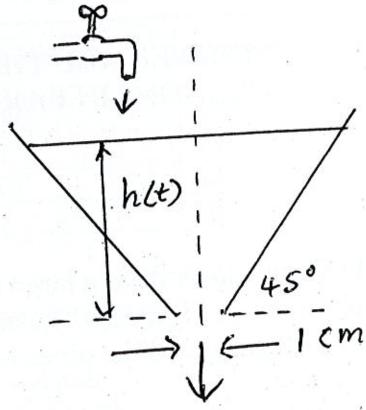

Figure 3

3) A tank has the shape of a cone with half angle 45 degrees, as shown in Figure 3. The tank is filled with water from a tap, and at the same time discharges water to the atmosphere through a hole at the bottom, as shown in the figure. The diameter of the hole is 1 cm. At a certain time, **t**, the height of water in the tank is **h(t)**.

a) At a time $t = 0$ the tank is empty and the tap is opened. The discharge from the tap is constant for $t \geq 0$. Sketch the variation of the water level in the tank with time. Explain your answer.

b) Calculate the steady water level in the tank when the discharge from the tap is 500 ml/s. Assume reasonable values for any parameters that are not given.

c) The tap is closed completely after the steady water level calculated in section b) is reached, while water is allowed to flow out through the hole at the bottom of the tank. Calculate the time taken for the water level in the tank to reduce to half the steady water level calculated in section b). Explain your answer.

PART B

Answer **any two** questions

4) A pipe has a circular cross-section and is inclined at 45° to the horizontal, as shown in Figure 4. The diameter of the pipe changes from 2 cm at A to 5 cm at B, as shown in the figure. The distance between A and B is 1 m . Water flows up the pipe, in the direction AB, at a discharge of 0.5 litres/s .

Simple water manometers are connected to A and B. The water level in the manometer connected to A is found to be 85 cm above the level of A while the water level level in the manometer connected to B is found to be 10 cm above the level of B, as shown in the figure.

a) Calculate the total head at A. Identify your elevation datum.

b) Calculate the total head at B using the same elevation datum.

c) Explain why the total head at B is less than the total head at A.

d) Calculate the rate of energy loss between A and B.

e) If a U-tube mercury manometer is connected between A and B, show, on a neat diagram, the difference in the mercury levels in the two arms of the manometer.

f) Calculate the difference in the mercury levels in the two arms of the manometer. (The density of water is 1000 kg/m^3 and the density of mercury is 13,600 kg/m^3).

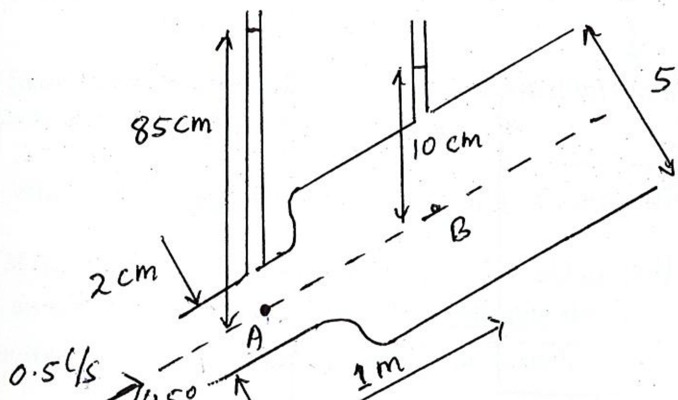

Figure 4

5) a) Explain, using a neat figure, how a domestic water meter works.

b) Explain what is meant by the phrase "calibration of a measuring instrument".

c) Describe how you would calibrate a domestic water meter.

d) Explain, using a neat diagram, how a pitot-static tube works.

e) Derive a relationship between what is observed in a pitot-static tube (i.e. the actual readings taken) and the quantity that is measured by a pitot-static tube.

6) The flow through a circular orifice is studied using a constant-head tank as shown in Figure 6 . The position of the jet is measured as shown in the figure. The discharge through the orifice is measured by recording the volume of water collected from the jet in a given time. The diameter of the orifice is 5 mm .

When the head in the tank is 1 m (H = 1 m) , the jet passes through a point that is 40.0 cm away from the tank in the direction of the tank and 4.4 cm below the orifice (x = 40 cm , y = 4.4 cm) . It takes 1 second to collect a volume of 20 ml of water from the jet.

a) Derive a relationship between the discharge through the orifice and the steady water level, H, in the tank. State all your assumptions.

b) Define the Coefficient of Discharge, Coefficient of Velocity and the Coefficient of Contraction when considering the flow through the orifice

c) Explain why these coefficients are introduced in the derivation of the relationship in section a).

d) Use the given measurements to estimate the Coefficients of Discharge, Velocity and Contraction.

e) How would you improve the accuracy of this experiment? Explain your answer.

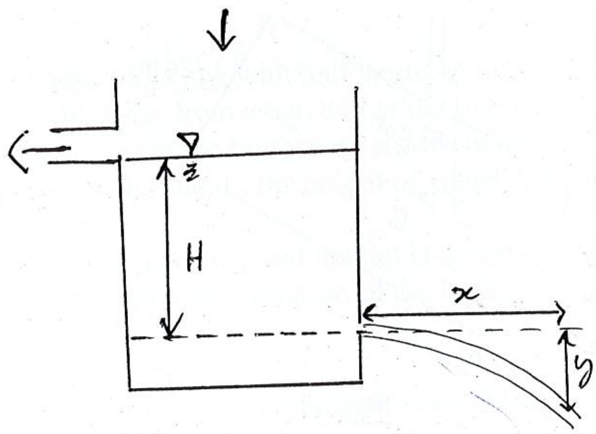

Figure 6

7) A student studies the effect of friction on the flow in a pipe using the apparatus shown in Figure 7. The apparatus consists of a long, horizontal pipe of diameter 50 mm . Two simple manometer tubes are fixed at two points A and B, which are 1 m apart as shown in the figure.

The student measures difference in the water levels in the manometers for four values of the discharge in the pipe. The results are given in Table 7. The density of water is 1000 kg/m3 and the kinematic viscosity of water is 1 x 10^{-6} m^2/s .

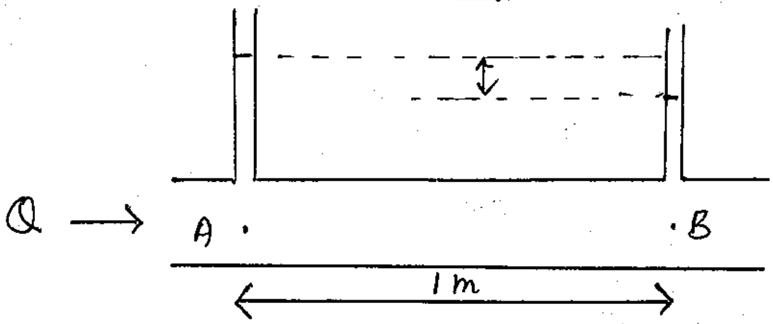

Figure 7

Discharge (litres/s)	0.6	1.3	1.9	2.5
Difference in Manometer Readings (mm)	2.0	7.5	15.0	23.0

Table 7

a) State Newton's law of viscosity as an equation and identify all the variables in the equation.

b) What are the dimension and the SI unit of the coefficient of dynamic viscosity?

c) If the head loss due to friction, h_f, is related to the average velocity in the pipe, v , by an equation of the form $h_f \propto v^n$, estimate the value of the exponent "n" using the results of the experiment. Explain your answer.

d) Calculate the friction factor for the first set of measurements.

e) Calculate the lowest value of the Reynolds number for the experiment.

f) Was the experiment carried out for Laminar Flow or Turbulent Flow? Explain your answer.

8) A small river has a catchment area of 150 km^2 at a certain location. A thunderstorm results in a certain rainfall over the catchment area during a 4 hour period, beginning at 1800 on the 1st of September.

The discharge in the river was measured from time the storm began and the results are presented in Table 8.

Time	1800 on 1/9	2100 on 1/9	2400 on 1/9	0300 on 2/9	0600 on 2/9	0900 on 2/9	1200 on 2/9	1500 on 2/9	1800 on 2/9
Discharge (m^3/s)	10	180	475	315	208	120	60	30	10

Table 8

a) Define the runoff coefficient.

b) Explain why the runoff coefficient should always take a value less than 1 .

c) What is meant by "base flow" in a flood hydrograph?

d) Sketch the hydrograph and estimate the base flow and the peak flow.

e) Assuming a value of 0.7 for the runoff coefficient, estimate the total average rainfall that fell on the catchment during the thunderstorm.

f) If a dam is constructed upstream of the measurement location sketch the hydrograph that you would expect to observe for the same storm and explain the differences from the observed hydrograph.