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 2008/2009

Time Allowed : **Three Hours** *Index No.*

Date : 28th March, 2009 Time : 1330 – 1630

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 (density 1000 kg/m^3) flows from Tank X (of cross-section area 10 m^2) to Tank Y (of cross-section area 10 m^2) through the pipe AB as shown in Figure 1. Water flows out of Tank Y through the pipeline CDEFG and is discharged to the atmosphere at G. A turbine, of efficiency 90%, is located between E and F. The lengths of the pipes AB, CD, DE and FG are 10 m, 20 m, 10 m and 10 m, respectively. All the pipes have a diameter of 2.5 cm and a friction factor of 0.01.

At a certain time the water level in Tank X is found to be 0.5 m above the water level in Tank Y.

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, through A, B, C, D, E and F to G.

b) List the head losses between O and G.

c) Calculate the discharge at G. Assume steady flow. Select reasonable values for any quantities that are not specified.

d) Calculate the mechanical energy extracted by the turbine.

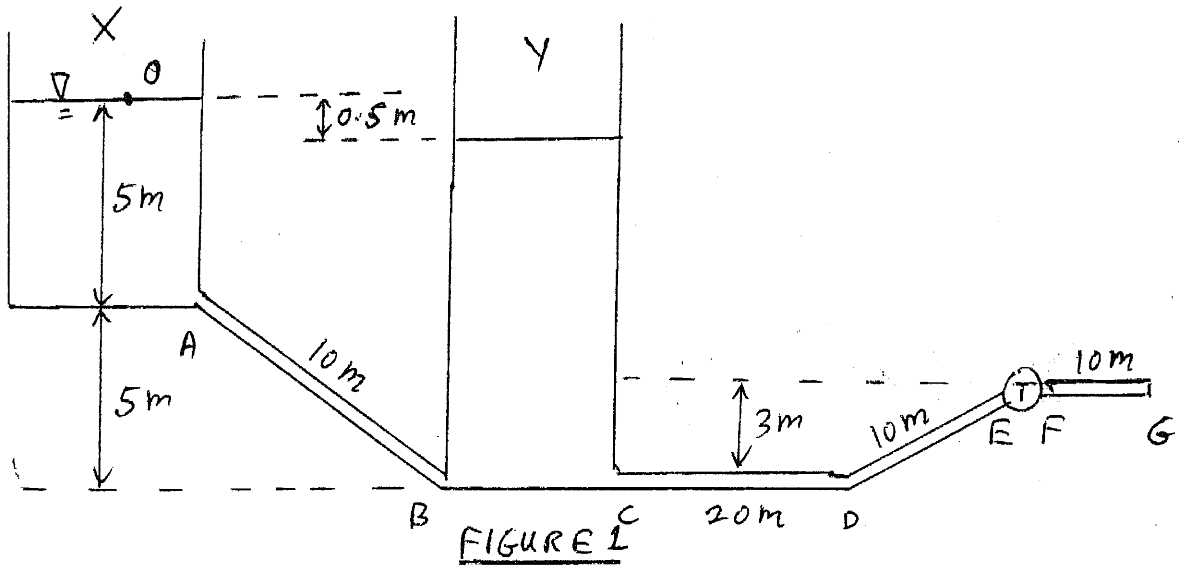

FIGURE 1

2) Water (of density 1000 kg/m^3) flows through the horizontal pipe AB and discharges to the atmosphere through the nozzle BC as shown in Figure 2. The diameter of AB is 5 cm while the diameter of the exit of the nozzle is 1 cm.

One end of a U-tube mercury (density 13,600 kg/m^3) manometer is connected to B, while the other end is left open to the atmosphere, as shown in the figure. When the discharge through the pipe is 0.2 litres/second it is found that the rate of energy loss in the nozzle is 0.06 W.

a) Show, on a neat diagram, the levels of mercury in the U-tube mercury manometer.

b) Calculate the difference of the levels of mercury in the U-tube mercury manometer.

c) Calculate the flux of momentum at B and C.

d) Calculate the net horizontal force exerted on the nozzle BC by the flow of water through it. State all your assumptions and explain your answer.

e) If the diameter of the nozzle at C is reduced to 0.5 cm while the discharge is kept the same, explain what would happen to the

i) force on the nozzle
ii) level difference in the U-tube mercury manometer
iii) rate of energy loss in the nozzle

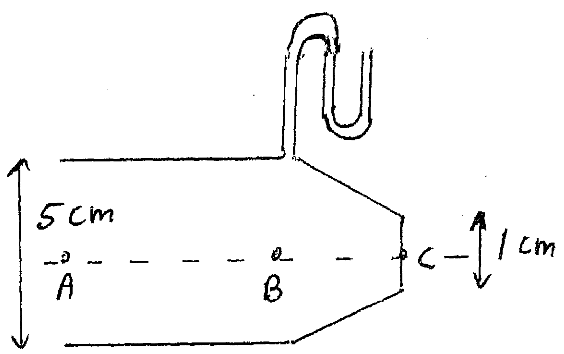

FIGURE 2

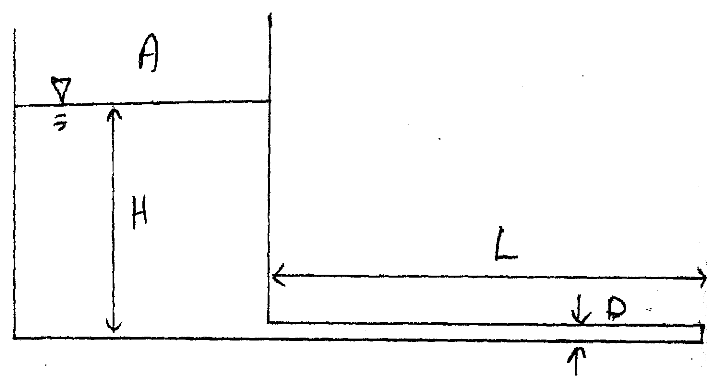

FIGURE 3

3) A water tank, of cross-section area, **A**, discharges through a very long pipe of length, **L**, and diameter **D**, as shown in Figure 3. The water level in the tank is **H**. A student analyzing this problem obtains a relationship between the velocity in the pipe, **V**, and the water level, **H**, as $H = \frac{fLV^2}{2gD}$. The student goes on to derive the equations

$$H = \frac{32\nu LV}{gD^2} \quad \text{(Eq. 1)} \qquad \text{and} \qquad \frac{dH}{dt} = -H\left(\frac{\pi g D^4}{128\nu LA}\right) \quad \text{(Eq. 2)}$$

where **ν** is the kinematic viscosity of water (equal to 10^{-6} m^2/s) and **g** the acceleration due to gravity.

a) Derive Eq. 1 above stating the fundamental principles used and explaining the assumptions made by the student. Note that the pipe is very long.

b) Derive Eq. 2 above stating the fundamental principles used and explaining the assumptions made.

c) If **L = 100 m**, **D = 1 cm** and **A = 1 m^2**, calculate the time taken for the water level in the tank to fall from **H = 0.3 m** to **H = 0.1 m**. Verify that all the assumptions made in deriving the equations are satisfied.

PART B

Answer any **two** questions.

4) The equation $\frac{1}{\sqrt{f}} = 2\log_{10}\left(\frac{\text{Re}\sqrt{f}}{2}\right) - 0.4$ is a relationship between the friction factor, **f**, and the Reynolds Number, **Re**.

a) Define the Reynolds Number.

b) State Newtons Law of viscosity.

c) Describe the flow condition for which this equation is valid.

Two tanks, X and Y, are connected by a pipe AB as shown in Figure 4. Both tanks have a cross-sectional area of 5 m^2. The pipe AB has a length of 10 m and a diameter of 5 cm. At a certain time water (density 1000 kg/m3 and dynamic viscosity 0.001 Pa s) flows from Tank X to Tank Y and the difference in the water levels in the tanks is observed to be 1 m, as shown in the figure.

d) Use the given relationship between the friction factor and the Reynolds' Number to calculate the discharge in the pipe at this time. State all your assumptions and explain your answer.

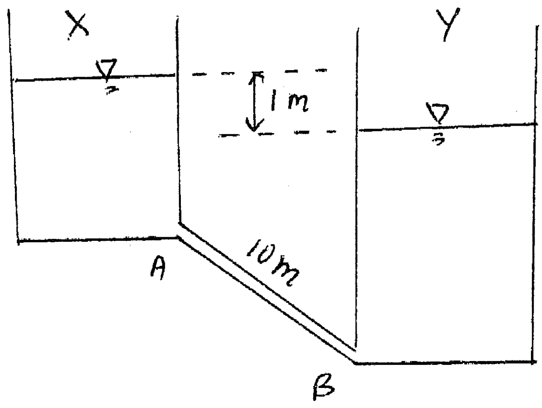

FIGURE 4

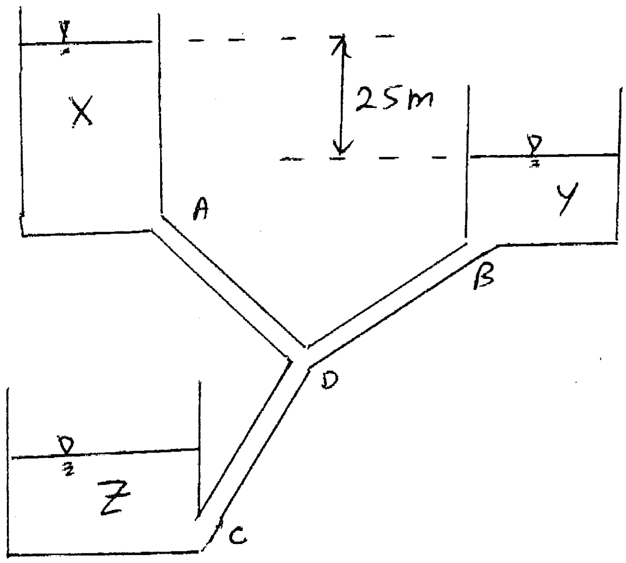

FIGURE 5

5) Three tanks, X, Y and Z, are connected by three pipes, AD, BD and CD, through a junction, D, as shown in Figure 5. The tanks are open to the atmosphere, and have constant cross-section areas of 120 m^2.

The pipes AD, BD and CD are all identical – with a diameter of 10 cm and a length of 100 m. At a certain time the free surface of Tank X is 25 m above the free surface of Tank Y. The water level of Tank X is decreasing at a rate of 0.7 mm/s while the water level of Tank Y is increasing at a rate of 0.2 mm/s.

a) Calculate the rate of change of the water level in Tank Z at this time. Explain your answer.

b) Calculate the friction factor of the pipes. Assume that pipe friction is the only source of energy losses. State all your assumptions and explain your answer.

6) a) Describe, with a neat sketch, the important features of a centrifugal pump. Indicate the direction of the flow of water on your sketch.

b) Give a brief explanation of how a centrifugal pump is able to increase the head of the fluid.

c) Explain how the results of the Pump Test you carried out in the Laboratory Classes can be used in practice.

d) Explain what is meant by cavitation.

e) How would you avoid cavitation in the design of pipe systems?

7) a) Discusses the relative advantages of V-notch and Rectangular Weirs in the measurement of the discharge in open channels.

b) Define the Manning's coefficient in open channel flow.

c) What is the relationship between the Manning's coefficient and the properties of the channel surface?

d) How is the knowledge of the Manning's coefficient useful in the practice of engineering?

A long, straight open channel has a uniform trapezoidal cross-section. The bottom width of the channel is 1 m, while the side slopes are 1 horizontal to 1 vertical. The slope of the channel is 0.0005 and the Manning's coefficient of the channel is 0.015 .

e) Calculate the depth of flow when this channel carries a flow if 1.5 m^3/s under uniform flow conditions.

8) Several areas of Colombo are drained by the canal that flows past the Open University. This canal is connected to the sea at Wellawatta (with a small branch leading to the sea at Dehiwala). The catchment area of the canal at the Open University is about 35 km^2 .

A heavy storm causes a rainfall of 150 mm over Colombo in four hours beginning at 0600 on the 1st of November. Due to this rainfall the discharge in the canal at the Open University varied linearly from 1 m^3/s at 0600 to a maximum value at 1200 on the 1st of November. The discharge then decreased linearly to 50% of this maximum value by 2400 on the 1st and then decreased linearly back to 3 m^3/s by 2400 on the 3rd (66 hours after the start of the storm).

a) Sketch the hydrograph and identify the peak flow and the base flow.
b) Calculate the total volume of precipitation in this catchment due to this storm.
d) Assuming an average runoff coefficient of 0.85 for this catchment, calculate the peak discharge in the canal.
e) If the same storm takes place 10 years in the future, what differences would you expect to see in the flood hydograph? Explain your answer with a sketch.
f) If the same storm takes place over a catchment of similar area in Kandy, what differences would you expect in the flood hydrographs in Kandy and Colombo? Explain your answer with a sketch.