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 2007/2008

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

Date : 09th May, 2008 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) A rectangular parking area has a length of 50 m and a width of 25 m. The surface of the parking area is of sandy soil and is covered with grass. The parking area is surrounded by a drain, as shown in Figure 1.

A student makes measurements of the rainfall onto the parking area and the discharge in the drain at point A. The rainfall is measured by collecting the rain into a measuring cylinder with a funnel. The funnel diameter is 20 cm. The volume of rain water collected for three time intervals is given in Table 3a. There is no rain after 0620.

Time Interval	0600 - 0605	0605 - 0615	0615 - 0620
Collected Volume of Rainfall (ml)	375	445	170

Table 3a

The measurements of the discharge in the drain are given in Table 3b.

Time	0600	0610	0615	0620	0630	0645	0700	0730
Discharge (l/s)	0.5	4.5	7.5	9.1	3.5	2.1	1.0	0.5

Table 3b

a) What is a hydrograph?

b) Explain what is meant by the base flow in a hydrograph.

c) What is the base flow for these measurements?

d) Estimate the runoff coefficient of the parking area. State all your assumptions and explain your answer.

e) What will happen to the runoff coefficient if the parking area is paved with asphalt?

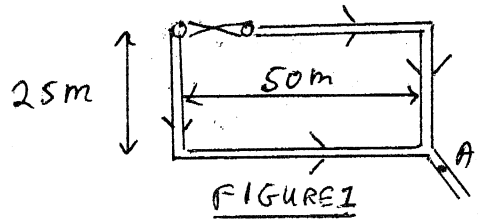

FIGURE 1

2) Water (density 1000 kg/m^3) flows from Tank X to Tank Y through a pipeline ABCDEF, as shown in Figure 2. All the pipes have a diameter of 1 cm and a friction factor of 0.01 . Pipes AB and BC are both 10 m long, pipes CD and DE are both 15 m long, while pipe EF is 20 m long. Tanks X and Y have uniform cross sections and the cross-sectional area of Tank X is 10 m^2 while the cross-sectional area of Tank Y is 15 m^2 .

When the water levels of the tanks are as shown in Figure 2, it is found that the lowest pressure in the pipeline is 1.6 kPa below atmospheric pressure.

a) Sketch, on graphs placed one above the other, the variation of the Elevation Head, Velocity Head, Pressure Head and Total Head from point O, on the free surface of Tank X, through the pipeline ABCDEF to point P, on the free surface of Tank Y. State your elevation datum.

b) List the head losses from point O to point P.

c) Explain why there is a head loss at A.

d) Calculate the rate of change of the water levels in Tanks X and Y at this time. Assume reasonable values for any parameters that are not given. State all your assumptions and explain your answer.

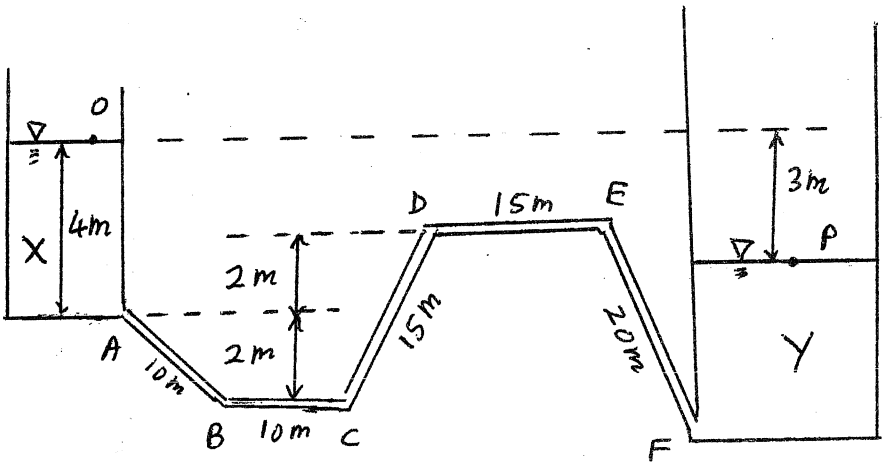

FIGURE 2

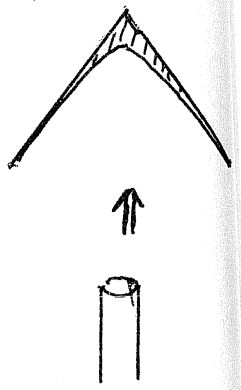

FIGURE 3

3) A student measures the force exerted by a jet of water on a conical target. The student uses the arrangement shown in Figure 3, where the target is directly above the jet. The student derives the theoretical equation for the force as $F = \rho \frac{Q^2}{A}(1-\cos\theta)$, where **F** is the force, **ρ** the density of water, **Q** the discharge of the jet and **A** the cross-sectional area of the jet.

a) Derive this theoretical equation, beginning from the basic principles of hydraulics.

b) Show, in a neat diagram, how the angle **θ** in this equation is defined.

c) List three important assumptions that have to be made to derive this theoretical equation. Please list only the assumptions that are important for this particular problem.

d) Consider the basic principles used in section a) and discuss, **for each of the assumptions listed in section c)**, whether the assumption will result in the force calculated by the theoretical equation being greater than or less than the actual force on the target.

PART B

Answer any **two** questions.

4) A student wants to make an instrument to measure the discharge in a horizontal pipeline of circular cross-section. The student places a thin plate across the pipeline. The plate has a small hole – of circular cross section – at its centre, as shown in Figure 4. The student plans to connect a U-tube mercury manometer to two points in the pipeline. She then plans to use a theoretical equation to relate the level difference in the manometer to the discharge in the pipeline.

a) Show, using a neat diagram, where the manometer should be connected to the pipe.

b) Show, using a neat diagram, the difference in the levels of the U-tube mercury manometer when the flow is in the direction shown in Figure 4.

c) Explain, using a neat diagram of the streamlines of the flow through this instrument, why there is a difference in the levels of the U-tube mercury manometer.

d) Explain how the student can obtain a theoretical relationship between the level difference in the manometer and the discharge in the pipeline. You **do not** have to derive a relationship – you only have to explain how it can be derived.

5) A horizontal, cylindrical pipe has a sudden change in diameter as shown in Figure 5. The diameter changes from 2.5 cm at A to 5 cm at B. The discharge in the pipe is 1 l/s from A to B. A U-tube mercury manometer is connected to A and B. The difference in levels in the manometer is 13 mm, with the higher level in the tube connected to A as shown. The density of water is 1000 kg/m^3 and the density of mercury is 13,600 kg/m^3 .

a) Explain, by sketching the streamlines of the flow, why there is a loss of energy at the sudden change in diameter.

b) Calculate the head loss between A and B.

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

d) If the pressure at A is 20 kPa calculate the force on the pipe section between A and B.

6) a) Sketch the Moody diagram. Identify and define the variables on the axes of the diagram.

b) Describe the different regions of the Moody diagram and explain their differences.

c) Explain how the Moody diagram has been obtained.

d) A pipeline leads from one overhead tank to another as shown in Figure 6. The difference in water levels of the two tanks is H while the pipeline has a length L , a diameter d and an equivalent roughness of k . Explain how you would use this information and the Moody diagram to calculate the discharge in the pipeline. Note that you have only to explain the method, not solve the problem completely.

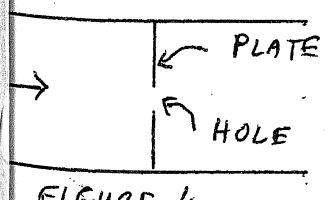

FIGURE 4

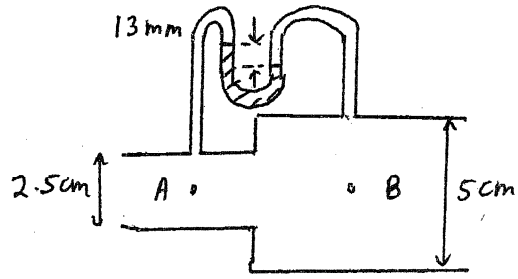

FIGURE 5

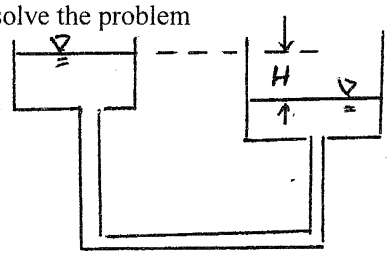

FIGURE 6

7) Figure 7 shows the pipe system in a house. Water is distributed from an overhead tank, X, to two Taps, D and E, through the pipes AB, BD, BC, and CE. The elevations of the points A, B, C, D, and E with respect to the water level in the Tank X are shown on the figure.

The lengths of the pipes are as follows : AB = 4 m , BC = 3 m , BD = 4 m and CE = 5 m . All the pipes have a diameter of 25 mm and a friction factor of 0.01 .

a) Taps D and E are opened fully. Calculate the discharge through Taps D and E. Assume reasonable values for any coefficients not specified. Explain your calculation.

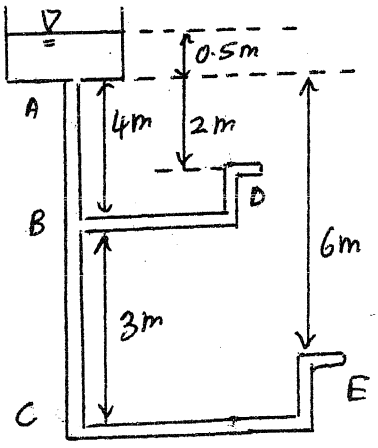

FIGURE 7

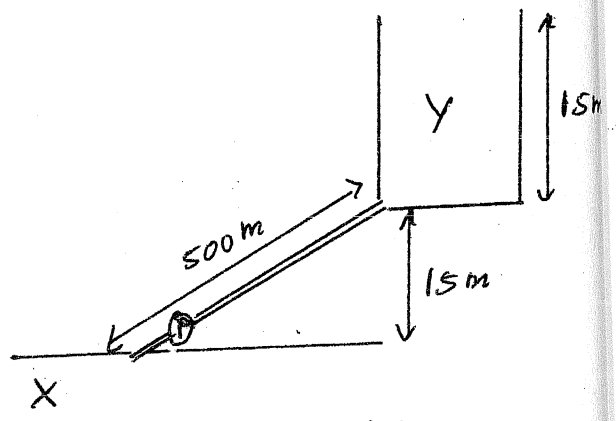

FIGURE 8

8) A centrifugal pump is used to pump water from Reservoir X to Tank Y, as shown in Figure 8. The pipeline AB has a length of 500 m , a diameter of 50 mm and a friction factor of 0.01. Tank Y has a uniform cross-sectional area of 5 m^2 and a maximum depth of 15 m . The bottom of Tank Y is 10 m above the water level of Reservoir X and Tank Y is empty when pumping begins.

The pumps is tested at its operating speed and the results are given in Table 8.

Discharge (l/s)	0	10	20	30	40
Head (m)	20	18	15	10	2

Table 8

a) What is the maximum water level that can be achieved in Tank Y? Explain your answer.

b) Estimate, as accurately as you can, the time taken to achieve the maximum water level in Tank Y when the pumps are working at their operating speed. State all your assumptions and explain your answer.