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

CEX 3232 / CED 1202 - HYDRAULICS AND HYDROLOGY

FINAL EXAMINATION 2005/2006

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

Date : 13th March, 2006 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 large tank, X, contains water (density 1000 kg/m^3) to a depth of 15 m as shown in Figure 1. Water flows out of this tank through the pipeline ABCDEFGHI as shown. A turbine of efficiency 85% is located between G and H. The pipes AB, BC, EF, FG and HI have a diameter of 1 cm and a friction factor of 0.01. The pipe diameter expands linearly from 1 cm to 5 cm from C to D and remains constant at 5 cm from D to E. The energy losses between C and E are found to be equal to the velocity head in the pipe BC. The discharge through the pipeline is found to be 0.2 litres/second. The lengths of AB, BC, EF, FG and HI are 20 m, 10 m, 10 m, 30 m and 20 m, respectively.

a) Sketch, on graphs placed one above the other, the variation of elevation, velocity, pressure and total head from the point O, on the free surface of Tank X, to I.

b) Calculate the mechanical power produced by the turbine. Assume any values that are not given and explain your answer.

c) Calculate the lowest pressure in the pipeline.

d) Can the power produced by the turbine be increased by moving it to I? Explain your answer.

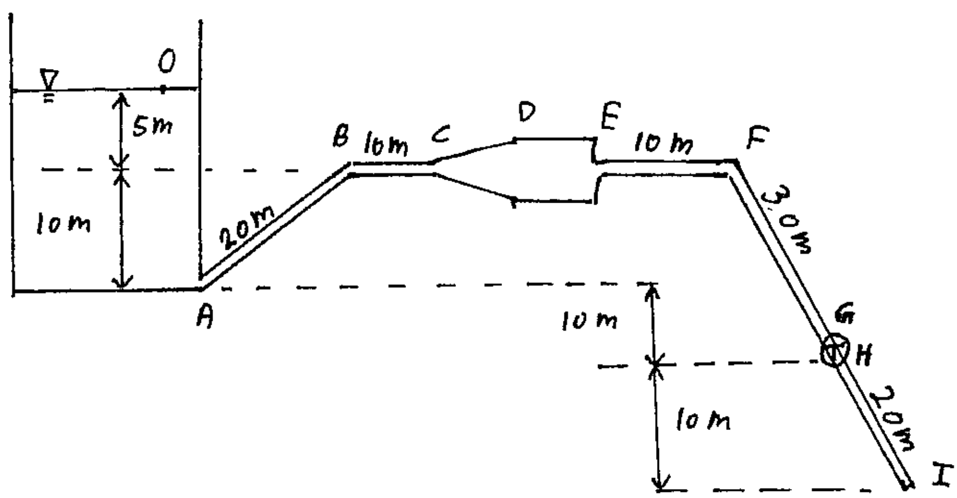

FIGURE 1

2) A tank, X, is placed on a weighing scale as shown in Figure 2. The weight of the empty tank is 10 kg and the cross-sectional area of the tank is 0.1 m^2. The tank has a discharge pipe, ABC, of diameter 2 cm as shown. Pipes AB and BC each have a length of 0.3 m and a friction factor of 0.01. A downward pointing pipe, of diameter 1 cm, is placed 5 m above the centre of the tank as shown. At time t = 0 the tank is empty and a water (density 1000 kg/m^3) is discharged from the pipe towards the tank at a rate of 1 litre/second.

a) Sketch the variation of the reading on the weighing scale with time. Explain your answer.

b) Obtain a relationship between the water level in the tank and the discharge through ABC. Assume reasonable values for any variables that are not specified.

c) Calculate the maximum water level in the tank.

d) Calculate the maximum reading on the weighing scale.

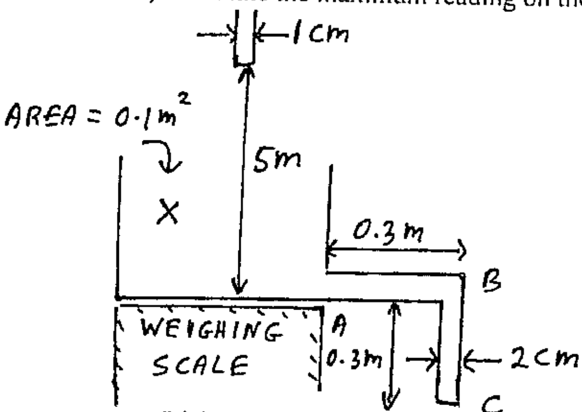

FIGURE 2

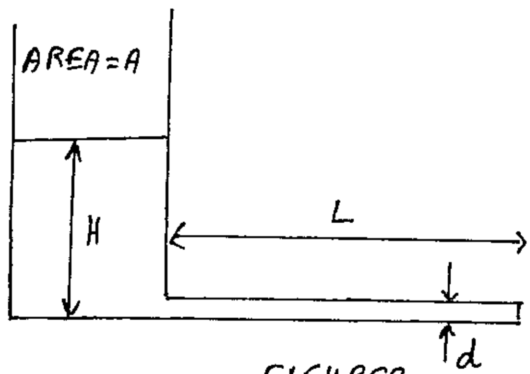

FIGURE3

3) A student uses the apparatus shown in Figure 3 to estimate the friction factor of a steel pipe of length **L** and diameter **d**. The internal surface of the pipe is very rough. The apparatus consists of a tank of cross-sectional area, **A**, which discharges through the pipe to the atmosphere as shown.

The student derives the relationship between the water level in the tank, **H**, and the velocity in the pipe, **V**, to be given by equation (3a) below. The student further derives equation (3b), for the time, **t**, taken for the water level in the tank to drop from H_1 to H_2. Here **f** is the friction factor of the pipe.

$$V = \sqrt{\frac{2gdH}{fL}} \qquad (3a)$$

$$f = \frac{\pi^2 d^5 g t^2}{32A^2 L\left(\sqrt{H_1} - \sqrt{H_2}\right)^2} \qquad (3b)$$

a) Derive equation (3a). You should state the fundamental principles that you use and explain your assumptions.

b) Derive equation (3b). You should state the fundamental principles that you use and explain your assumptions.

For the apparatus used by the student the relevant values are A = 2 m^2, d = 0.05 m and L = 10 m. The experiment is conducted and it is found that it takes t = 1045 seconds for the water level in the tank to reduce from H = 3 m to H = 0.1 m.

c) Estimate the friction factor of the pipe using equation (3b).

d) Discuss whether the assumptions made in deriving equations (3a) and (3b) have been satisfied in this experiment. The density of water is 1000 kg/m^3 and the dynamic viscosity of water is 0.001 Pa s.

PART B

Answer any **two** of the **five** questions.

4) 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 4. 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.

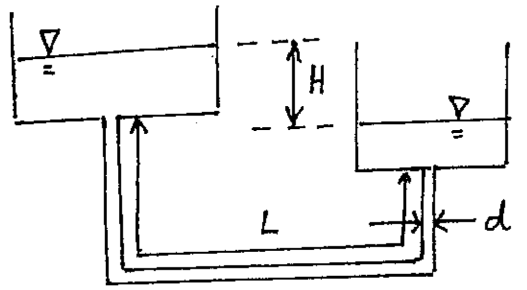

FIGURE 4

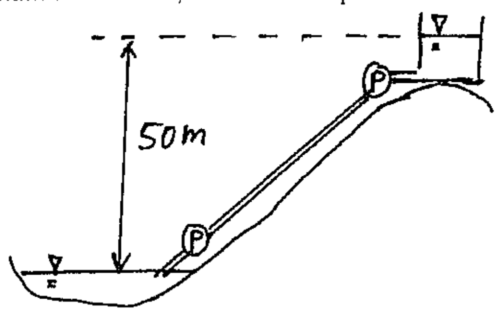

FIGURE 5

5) Water has to be pumped from a reservoir to a water tank on top of a hill, as shown in Figure 5. The length of the pipeline is 500 m and the water level in the tank is 50 m above the water level of the reservoir. The pipe has a diameter of 25 mm and a friction factor of 0.01 . Only one type of pump is available in the area. This pump is tested at its operating speed and the results are given in Table 5. It is decided to use two of these pumps in series as shown in the figure, with one pump placed near the reservoir and one placed at the top of the hill.

Pump Head (m)	40	35	30	25	20	10
Discharge (litre/s)	0	1	1.5	1.75	2	2.25

Table 5

a) Explain why two pumps have to be used.

b) Calculate the discharge in the pipeline. Assume reasonable values for any variables not given and explain your answer.

c) What would change if the second pump was also placed near the reservoir, instead of on top of the hill? Explain your answer.

6) An equation used in connection with the Orifice Meter is $Q = C_d A_2 \left[1 - \left(\frac{A_2}{A_1}\right)^2\right]^{-1/2} [2g\Delta h]^{1/2}$

a) Draw a neat sketch of an Orifice Meter. Indicate the locations where manometers should be connected.

b) Identify, using the sketch drawn above where necessary, **Q**, $\mathbf{A_2}$, $\mathbf{A_1}$ and $\mathbf{\Delta h}$ in this equation.

(... continued)

6) (… continued)

c) Identify and define C_d in this equation.

d) Sketch the streamlines of the flow through the Orifice Meter.

e) If a U-tube mercury manometer is connected to the orifice meter, show on a neat sketch the direction of flow through the Orifice Meter and the difference in mercury levels in the manometer.

f) Explain what is meant by "calibration" and describe how you would calibrate an Orifice Meter.

7) A long open channel has a rectangular cross-section and a width of 1 m . The bed of the channel drops 150 cm over a 1 km length of the channel. The Manning's coefficient of the channel is 0.015 . The channel carries a steady discharge of 75 litres/second .

a) Explain what is meant by "uniform flow".

b) Calculate the depth of flow in the channel when the flow is uniform.

c) Sketch a small control volume in a uniform, open channel flow and mark the forces acting on the fluid control volume.

d) State the general equation for the conservation of momentum for a fluid control volume.

e) Calculate the average shear stress on the channel bottom and sides.

8) Many areas of Colombo such as Borella, Rajagiriya, Kotte and Dematagoda are drained by the canal that passes the Open University. This canal is connected to the sea at Wellawatta (with a small branch leading to the sea at Dehiwala). A heavy storm causes a rainfall of 150 mm over Colombo in four hours beginning at 0600 on the 1st of September. Due to this rainfall the discharge in the canal varied linearly from 1 m^3/s at 0600 to a maximum value at 1200. 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) Explain why there is a flow in the canal before the storm begins.

c) Explain what is meant by "catchment area".

d) If the catchment area of the canal at the Open University is 150 km^2, calculate the total volume of precipitation in this catchment due to this storm.

e) Assuming an average runoff coefficient of 0.85 for this catchment, calculate the peak discharge in the canal.

f) 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.